Piranha

Reference Manual - English - Version 5.5C

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Welcome to the Piranha

The Piranha is an X-ray Analyser/Multimeter for everybody working with Quality Assurance and Service of X-ray systems.

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Intended Use of the Piranha System

Accessory to diagnostic X-ray equipment to be used as an electrometer. Together with external probes it is to be used for independent service and quality control, as well as measurements of kerma, kerma rate, kVp, tube current, exposure time, luminance, and illuminance within limitations stated below.

If installed according to accompanying documents, the product is intended to be used together with all diagnostic X-ray equipment except for:
- therapeutical X-ray sources.
- X-ray equipment with tube potential below 18 kV.
- X-ray equipment on which the instrument cannot be mounted properly, e.g. equipment where the beam field size is narrower than the active part of the detector.
- specific types of X-ray equipment listed in the instructions for use or in additional information from the manufacturer.

With the X-ray installation in stand-by conditions without patients present, the product is intended to be used:
- to provide the operator with information on radiation beam parameters that might influence further steps in an examination but not an ongoing exposure.
- for assessing the performance of the X-ray equipment.
- for evaluation of examination techniques and procedures.
- for service and maintenance measurements.
- for quality control measurements.
- for educational purposes, authority supervision etc.

The product is intended to be used by hospital physicists, X-ray engineers, manufacturer's service teams, and other professionals with similar tasks and competencies. The operator needs a short training to be able to use the product as intended. This training can be achieved either by careful study of the manual, studies of the built-in help function in measurement software or, on request, in a short course ordered from the manufacturer.

The product is intended to be used inside X-ray rooms ready for clinical use and can safely be left switched on and in any measuring mode in the vicinity of patients.

The product is NOT intended to be used:
- for direct control of diagnostic X-ray equipment performance during irradiation of a patient.
- so that patients or other unqualified persons can change settings of operating parameters during and immediately before and after measurements.

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Chapter 1

Introduction

1 Introduction

1.1 About this Manual

This manual is divided into a few main parts.

1. A general description of the Piranha.
2. Some theoretical background and basic principles.
3-4. Descriptions on performing measurements with the system for different modalities.
5. Description of different accessories for the Piranha.
6. Troubleshooting tips, an FAQ, and a glossary.

Users who use the Piranha with only a PC and Ocean are recommended to read at least the following topics:

- Introduction
- Description of the Piranha
- Measurements with the Piranha System

For the Piranha system, calibration data is stored inside the system. See section Managing Detector Calibrations 33 for more information.

Typographical Rules
Terms in **bold** face are references to texts on screenshots, like buttons and texts, and menu items. Other terms are *italicized*.

1.2 Introduction to the Piranha

Congratulations to your purchase of a Piranha. You have now in your hand the most powerful tool for X-ray analysis. It has been carefully designed to meet the needs of both standard QA applications as well as advanced service/repair/calibration of modern X-ray systems, while still being very simple and intuitive to use. It can measure all the required parameters such as kVp, exposure time, dose, HVL, Total Filtration, dose/pulse, dose rate, tube current, mAs, waveforms, and much more.

The Piranha can be used in two different ways:

- As a "meter" with a handheld computer and the QABrowser or a PC with Ocean Quick-Check.
- As a complete "QA-system" with a PC and the Ocean software.

This manual describes the Piranha. The QABrowser and the PC software, Ocean, are described in detail in separate manuals.

The Piranha system's main features are:

- Very easy and intuitive to use
- Accurate
- Active Compensation - No manual corrections are needed
- Measures on all modalities with one detector
- Specially designed measuring modes for pulsed waveforms
- Compact
- QABrowser or Ocean is used for control and data processing
- Waveform analyser

- USB and Bluetooth interface
- Free upgrade of firmware
- New and unique design

Free upgrades of the firmware (the software resident in the cabinet and measuring modules) are available on RTI Electronics Web site at http://www.rti.se.
If you have questions, comments, or feel that some functionality is missing, you are welcome to contact us at RTI Electronics at sales@rti.se. You can of course also call or send a fax (see notice section for details).

1.3 PC Requirements

To run the RTI Updater, the QABrowser Updater, and Ocean the following is required:

Minimum requirements
Windows XP, 2003, Vista, 7/8 32-bit, or 7/8 64-bit.
Pentium class 300 MHz, 64 MB RAM (24 MB free), 60 MB of HD [1]
USB port
Display and graphics card with at least 800×600 resolution

Recommended requirements
Windows 7/8 32-bit or 8 64-bit
Pentium class 500 MHz, 128 MB RAM (32 MB free), 100 MB HD
USB port
CD/DVD-ROM for installation
Internet connection for updates (Recommended)

1: Virtual memory and available hard drive space. Microsoft recommends that you have at least 20 % of your total HD space free for virtual memory.

1.4 Palm OS Computer Requirements

To run the QABrowser the following is required:

Minimum requirements
- PalmOS v5.0 or higher
- 16 MB of memory
- Colour screen with a resolution of 320×320 pixels
- Palm connection: Bluetooth wireless

Recommended requirements
- RTI Handheld Display or Palm Tungsten E2/TX
- Bluetooth wireless.

Chapter 2

Description of the Piranha

2 Description of the Piranha

2.1 Indicators and Connectors

The Piranha comes in a lot of different models, the external design is basically the same for all models (except for the External Probe port).

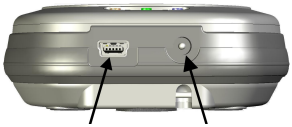
Edge: External Probe port (on some Piranha models)

Detector area
The rectangular marking indicates where the active detector area is located. The detector surface is located 10 mm below the surface, see section Specifications, Piranha 12. Minimum X-ray field is 3×21 mm.

The recommended field size is shown as red corners. (20×40 mm).

Power switch (on edge)
Turns the Piranha on and off

Indicators for charging, status, and Bluetooth



USB port

Palm charger output (not used)

The **USB port** is used when using RTI Updater to update the internal firmware. It can also be used when the Piranha is used together with a PC running the QA software Ocean. Note that the USB connector cannot be used when connecting to a handheld computer. The system is then powered from the PC via the USB cable. The PC however have a limited USB power output, so when fast charging is needed the power supply needs to be connected here. This is also possible when using the Bluetooth link to communicate with the Palm or PC. The port is marked **USB**.

The orange indicator for **Charging of batteries** is lit when charging is active. Note that charging is possible even when the power switch is off.

The blue indicator for **Bluetooth** is lit when the Bluetooth interface is active and discoverable.

The multi-coloured indicator for **Status** shows the status of the system, e.g. battery level as described below. Also works as **Power indicator**, one of the colours will light when the Piranha is on.

Battery level

The status indicator is used to show the battery level of the Piranha.

1. Starting a system running on batteries the status indicates for 3 seconds:
   - Green if battery level over 25 % (4 h left)
   - Yellow if battery level between 10 and 25 % (1½-4 h left)
   - Red if battery level below 10 % (<1½ h left).

   The idea is to get a quick indication when powering on the system if it will take me through today's work.

2. When running on batteries the status indicator shows:

Status colour	Running time left
Green	>2 hours
Yellow	>1 hours
Red	>15 minutes
Flashing red	<15 minutes

Note! You may also check the battery level in the QABrowser or in Ocean.

See section Power & Communication Specifications 11 for more information about battery charging and discharging times.

External Probe port and **Opening for filter position viewing**

Here you attach the external probes that come with some models of the Piranha. The port is marked **EXT**. **Note!** Not all models have this port.

The small square opening above may be used for monitoring the filter position inside the Piranha.

Product marking
Indicates the model of you Piranha, as well as the version, serial number, and applicable conformity markings.

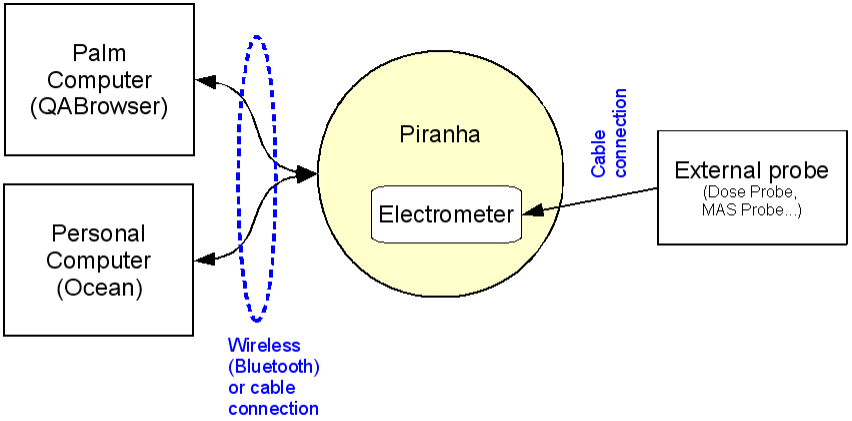
Power switch
Turns the Piranha on and off (Marked 1/0)

Camera thread for mounting the Piranha to a holder.

Attachment for **Safety strap**

The **Power switch** is used to turn the Piranha on and off. Piranha has several ways of saving power when it is inactive, but must be powered off manually since there is no auto-power off function.

Below a block diagram of a typical Piranha system is shown.



2.2 Setting Up the Piranha for the First Time

Before you use your Piranha for the first time, please do the following:

- Attach the external power supply.
- Charge the system for 16 hours.

Then continue according to the following section.

2.3 Setting Up the Piranha

To set up the Piranha:

1. Power on the Piranha using the power switch. Optionally you may connect the power supply.
2. Place the Piranha under the tube or mount the holder and HVL stand for positioning of the Piranha in the X-ray field. The stand allows you to position the Piranha (or the external Dose Probe) and HVL filters in any angle including upside-down. Use the light-field or other help to position the Piranha in the X-ray field. The Piranha detector is not sensitive for different field sizes as long as the entire sensitive detector area is irradiated, but try to keep the field size down to minimize scattering.

Note! It is also recommended to position the Piranha in such a way that the detector area is orientated perpendicular to the anode/cathode axis, to avoid the heel effect.
Recommended field size is 20×40 mm.

3. Connect with Handheld via Bluetooth, or with Ocean via included USB cable or via Bluetooth.

2.4 Hardware and Specifications

Specifications are valid after a warm-up time of one minute and presuming reference conditions. All specifications are for use together with the Piranha unless otherwise stated. All specifications can be changed without prior notice. RTI Electronics AB assumes no responsibility for any errors or consequential damages that may result from the misuse or misinterpretation of any information contained in these specifications.

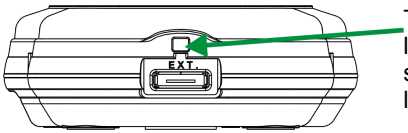
2.4.1 Piranha internal detector (Internal detector)

2.4.1.1 General

With the Piranha internal detector you will manage most of your measurements. Tube voltage, exposure time, dose, and dose rate are measured for all kinds of modalities: conventional radiography, fluoroscopy, pulsed fluoroscopy, cine, mammography, dental, panoramic dental, and CT (kVp only, not dose and doserate). In one exposure, the detector provides tube voltage, time, dose, dose rate, quick-HVL, and estimated total filtration on radiographic, fluoroscopic, dental, and CT exposures. On pulsed radiation and cine, also dose per pulse and pulse rate are measured. The Piranha internal detector is very sensitive and can measure peak tube voltage for as low outputs as 50 kV / 0.050 mA at 50 cm.

Typically the exposure time has to be at least 5 ms to get a kVp value but it depends on the waveform. On modern X-ray generators (high-frequency with fast rise and fall times) the peak tube voltage can normally be measured with exposure time as short as 1 ms. Dose and time values will be given for even shorter exposure times.

The estimations of total filtration and Quick-HVL are done from one single exposure using a combination of detector and filters in the Piranha. In situations when the total filtration cannot be automatically estimated, a "standard" HVL measurement may be required. All measured kVp and dose values measured with the Piranha are automatically compensated for the actual beam/radiation quality. This means that no manual corrections of measured data is needed.



The range indicator can be viewed behind a little lid, that can be pushed to the side. Make sure to close it afterwards, to avoid light leaking into the detector.

2.4.1.2 Power & Communication Specifications

Power Source

Power supply	5 V AC/DC adapter with Mini-USB connector, internal battery, or USB cable supply from PC.
Battery operated	One 2000 mAh Li-Ion battery. Operation time typically 15 hours. Typical charging times are listed below.
External power	100-240 V AC 50/60 Hz with external adapter.
Power output	On connector marked "5V OUT" for supply/charging of Palm. Only functional when AC/DC adapter is connected to USB port.

Typical Battery Charging and Running Times

Capacity	Running time	Charging time		
		Using Power supply	USB, Piranha ON	USB, Piranha OFF
50 %	7½ h	1½ h (90 min)	3½ h	17 h
80 %	12 h	2½ h (150 min)	6 h	27 h
90 %	13½ h	3¼ h (195 min)	7 h	30 h
100 %	15 h	5 h (300 min)	8½ h	32 h

Note that other mains power solutions that uses a regular USB cable to connect to the Piranha, will behave like USB in the table.

Communication

USB	Max 12 Mbit/s (USB v1.1)
Bluetooth	115 kbit/s

2.4.1.3 Specifications, Piranha

The inaccuracy is here defined as the root of the square sum of systematic errors, which has not been eliminated, and random errors (dispersion around a mean value). The calculation of the inaccuracy is based on 15 different measurements and with a confidence level of 95 %. Of the total inaccuracy, random error is 20 % and general inaccuracy is 80 %.
Note: Irradiation time is often called exposure time in daily use.

General

Operating temperature and relative humidity	15 – 35 °C at <80 % relative humidity
Storage temperature	–10 °C to +50 °C
Operating air pressure	Minimum 80 – 106 kPa

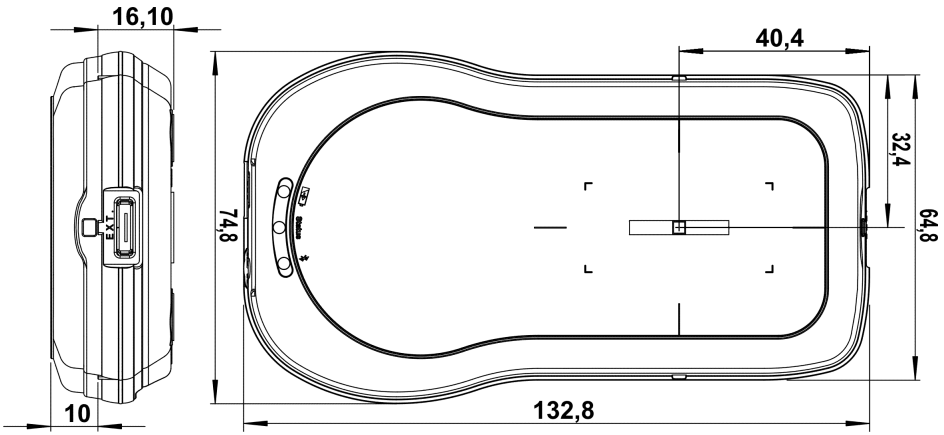
Reference conditions

Temperature	+18 °C to +23 °C
Relative humidity	50 %
Air pressure	101.3 kPa
X-ray field size	Inside the Piranha top panel. Calibration is done with field size typically 5 mm less than the size of the top panel.
Radiation quality **Radiography** **Mammography** **CT**	 70 kV, 2.5 mm Al 28 kV, 30 µm Mo 120 kV, 2.5 mm Al

Note: The reference conditions are given in reference to the IEC61674 standard.

Physical dimensions

Detector area	3 × 21.1 mm
Detector position	10 mm below top panel, as indicated in figure below and by a 3 mm rim on 3 edges.
Size	133 × 75 × 26 mm (5.2" × 2.9" × 1.02")
Weight	Approximately 405 g



Parameters

Tube voltage (kVp)	The average of all samples with compensation for the ripple (default method)
Time	Irradiation time (Exposure time)
Air kerma (Dose)	Measured air kerma (may be called dose or air kerma in this manual)
Air kerma rate (Dose rate)	Average air kerma rate (may be called dose rate or air kerma rate in this manual)
Total Filtration	Estimation of total filtration (for conventional radiography, fluoroscopy, dental, and CT)
Quick-HVL	Estimation of Half Value Layer (for conventional radiography, fluoroscopy, dental, mammography, and CT)
Half Value Layer	Standard HVL using filters for evaluation on radiography, fluoroscopy, dental, and mammography (all for both pulsed and conventional)
kV waveform	Waveform is calculated based on detector signals measured after different thickness of filtration.
Dose rate waveform	Signal measured from radiation detector (solid-state detector).

Measuring range and inaccuracy

Radiography, Fluoroscopy, and Dental

Parameter	RQ	Range	Inaccuracy	Resolution
kVp (standard) W / 3 mm Al	R1	35 – 160 kV	±1.5 %	4 digits (10 or 100 V)
kVp dental W / 3 mm Al	R1	35 – 105 kV	±1.5 %	As above
Irradiation time		0.1 ms – 2000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	0.5 ms 1 pulse
Air kerma (Dose) [2] with wide range option (WR)		0.7 µGy – 1000 Gy 15 nGy – 1000 Gy (2 µR – 100 kR)	±5 %	–
Air kerma rate [2] **(Dose rate)** with wide range option (WR)		10 µGy/s – 450 mGy/s [3] 15 nGy/s – 450 mGy/s [3] 1.7 µR/s – 50 R/s 0.1 mR/min – 3000 R/min	±5 % or ±7 nGy/s ±5 % or ±0.8 µR/s ±5 % or ±0.05 mR/min (for Irr. time >20 ms)	Typ. noise: 3 nGy/s
-Free run -High Sensitivity -Low Sensitivity		15 nGy/s – 12 mGy/s [2] 150 nGy/s – 12 mGy/s [2] 25 µGy/s – 450 mGy/s [2]	±5 % or ±7 nGy/s ±5 % or ±7 nGy/s ±5 % or ±0.1 µGy/s	Typ. noise: 3 nGy/s
Estimated total filtration		1.0 – 90 mm Al (full kV range)	±10 % or ±0.3 mm ±15 % >50 mm Al (60 – 120 kV, HF/DC, >10 µGy/s)	2 digits (0.1 or 1 mm)
Quick-HVL		1.2 – 14 mm Al [4] (50 – 150 kV)	±10 % or ±0.2 mm (60 – 120 kV, HF/DC, >10 µGy/s) [1]	3 digits (0.01 or 0.1 mm)

Note 1: This is valid for a tube with 14° anode angle. The HVL for a 22° anode is typically 0,5 mm lower (@ 80 kV, 3 mm TF).
Note 2: All kerma and kerma rate ranges, inaccuracy, and resolution figures are valid for product version 2 and higher of the Piranha.
Note 3: The Kerma rate is calculated as the Kerma (Dose) divided by the Irradiation time. See also Waveforms and Triggers 44.
Note 4: The HVL range is valid if also the TF is within its specified range. For high TF at high kV the HVL range may be limited by this.

Mammography

Parameter	RQ	Range	Inaccuracy	Resolution
kVp (standard)				
Mo / 30 µm Mo	M1	18 – 49 kV	±1.5 % or ±0.7 kV	4 digits
Mo / 25 µm Rh	M3	22 – 46 kV	±2 % or ±1 kV	(10 V)
Rh / 25 µm Rh	M4	25 – 49 kV	±2 % or ±1 kV	
W / 50 µm Rh [3]	M6 [3]	20 – 49 kV	±2 % or ±1 kV	
W / 0.50 mm Al [5]	M7 [5]	20 – 48 kV	±2 % or ±1 kV	
Mo / 1.0 mm Al	M8	18 – 49 kV	±2 % or ±1 kV	
W / 50 µm Ag	M10	20 – 40 kV	±2 % or ±1 kV	
W / 75 µm Ag	M11	20 – 40 kV	±2 % or ±1 kV	
W / 50 µm Rh (Gio)	M12	22 – 35 kV	±2 % or ±1 kV	
W / 0.70 mm Al	M15	20 – 49 kV	±1.5 % or ±0.7 kV	
W / 50 µm Ag (Sel) [4]	M16 [4]	22 – 39 kV	±2 % or ±1 kV	
W / 50 µm Rh (Sel) [4]	M17 [4]	22 – 39 kV	±2 % or ±1 kV	
kVp (optional)				
Mo / 30 µm Mo + + 2 mm Al	M1d	25 – 35 kV	±2 % or ±1 kV	4 digits (10 V)
Mo / 2.0 mm Al	M2	18 – 49 kV	±2 % or ±1 kV	
Irradiation time		0.1 ms – 2000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	0.5 ms 1 pulse
Air kerma (Dose) [1]		5 µGy – 1500 Gy	±5 %	–
with wide range option (WR)		25 nGy – 1500 Gy 3 µR – 150 kR	±5 %	
Air kerma rate [1] (Dose rate)		10 µGy/s – 750 mGy/s [2]	±5 % or ±12 nGy/s ±5 % or ±1.5 µR/s	Typ. noise: 6 nGy/s
with wide range option (WR)		25 nGy/s – 750 mGy/s [2] 30 µR/s – 86 R/s 1.8 mR/min – 5100 R/min	±5 % or ±0.1 mR/min (for Irr. time >20 ms)	
-Free run		25 nGy/s – 20 mGy/s	±5 % or ±12 nGy/s	Typ. noise: 6 nGy/s
-High Sensitivity		0.25 µGy/s – 20 mGy/s	±5 % or ±12 nGy/s	
-Low Sensitivity		45 µGy/s – 750 mGy/s	±5 % or ±0.2 µGy/s	

Note 1: All kerma and kerma rate ranges, inaccuracy, and resolution figures are valid for product version 2 and higher of the Piranha.
Note 2: The Kerma rate is calculated as the Kerma (Dose) divided by the Irradiation time. See also Waveforms and Triggers 44.
Note 3: The M6 (*W / 50 µm Rh)*, M10 (*W / 50 µm Ag),* and M15 (*W / 0.70 mm Al*) calibrations are suitable for the Hologic Selenia Dimensions and Fuji Amulet.
Note 4: The M16 (*W / 50 µm Ag (Sel)*) and M17 (*W / 50 µm Rh (Sel)*) calibrations are suitable for Hologic Selenia with W anode..
Note 5: The M7 (*W / 0.5 mmAl*) calibration is suitable for Philips MicroDose Mammography (Sectra).

Parameter	RQ	Range	Inaccuracy	Resolution
Quick-HVL [6]				
Mo / 30 µm Mo	M1	0.19 – 0.47 mm Al	±10 %	3 digits
Mo / 25 µm Rh	M3	0.31 – 0.52 mm Al		(0.001 mm)
Rh / 25 µm Rh	M4	0.33 – 0.60 mm Al		
W / 50 µm Rh	M6	0.37 – 0.75 mm Al		
W / 0.50 mm Al	M7	0.24 – 0.64 mm Al		
Mo / 1.0 mm Al	M8	0.31 – 0.68 mm Al		
W / 50 µm Ag	M10	0.34 – 0.69 mm Al		
W / 75 µm Ag	M11	0.41 – 0.79 mm Al		
W / 50 µm Rh (Gio)	M12	0.37 – 0.66 mm Al		
W / 0.70 mm Al	M15	0.27 – 0.81 mm Al		
W / 50 µm Ag (Sel)	M16	0.34 – 0.69 mm Al		
W / 50 µm Rh (Sel)	M17	0.37 – 0.66 mm Al		

Note 6: The Quick-HVL for mammography is only available for Piranhas with product version 2 and higher.

Computed Tomography

Parameter	RQ	Range	Inaccuracy	Resolution
kVp (standard)				
W / 3.0 mm Al	C1	45 – 160 kV	±1.5 %	4 digits (10 or 100 V)
W / 3 mm Al + 1.2 mm Ti (Siemens Straton (Siem1)) [2]	C3 [2]	75 – 145 kV		
GECT (7°) [2, 3]	C4 [2]	75 – 145 kV		
Acquillion 64 (Toshiba) [2]	C5 [2]	75 – 145 kV		
GECT (10.5°) [2, 3]	C6 [2]	65 – 150 kV		
Irradiation time		0.1 ms – 2000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	0.5 ms 1 pulse
Air kerma (Dose)		-	-	-
Estimated total filtration	C1 C6	1.5 – 90 mm Al (75 – 160 kV)	±10 % or ±0.3 mm ±15 % >50 mm Al (75 – 120 kV, HF/DC, >10 µGy/s)	2 digits (0.1 or 1 mm)
Quick-HVL	C1	1.2 – 14 mm Al (75 – 150 kV)	±10 % or ±0.2 mm (75 – 120 kV, HF/DC, >10 µGy/s) [1]	3 digits (0.01 or 0.1 mm)

Note 1: This is valid for a tube with 14° anode angle. The HVL for a 22° anode is typically 0,5 mm lower (@ 80 kV, 3 mm TF).

Note 2: The C3 and higher numbered calibrations are only available for product versions 2.0 or higher.

Note 3: The C4 (*GECT (7°)*) is suitable for all GE CT tubes which have a 7° anode angle as well as other manufacturers CT tubes and replacement tubes with a 7° anode angle. The C6 (*GECT (10.5°)*) is suitable for GE CT tubes with a 10.5° anode angle..

Pulses

Parameter	Range
Dose/pulse with wide range option (WR)	2.5 µGy/pulse - 60 kGy/pulse$_1$ 8 nGy/pulse - 60 kGy/pulse$_1$
Pulse dose rate with wide range option (WR)	Lower limit 10 µGy/s (70 mR/min), otherwise same as for air kerma rate. Lower limit 10 µGy/s (70 mR/min) otherwise, same as for air kerma rate.
Min. output peak dose rate - High Sensitivity - Low Sensitivity	dose rate (min. pulse width) 4 µGy/s (4 ms) / 30 µGy/s (0.5 ms) 20 µGy/s (4 ms) / 160 µGy/s (0.5 ms)
Pulse rate	0.5 – 180 Hz, resolution 0.5 Hz
Pulse width	4 ms - 2000 s
Duty cycle	5 - 95 %
Minimum pulse width - High Sensitivity - Low Sensitivity	pulse width (min. dose rate) 4 ms (4 µGy/s) / 0.5 ms (30 µGy/s) 4 ms (20 µGy/s) / 0.5 ms (160 µGy/s)
Minimum ripple (pulse top to bottom)	50 %
Irradiation time	1 – 65535 pulses, resolution 1 pulse

Note 1: Max dose/pulse depends on the pulse length.
Note 2: All kerma and kerma rate ranges, inaccuracy, and resolution figures are valid for product version 2 and higher of the Piranha.

Waveform recording time

At max sampling rate	1024 ms (2 kSa/s)
At min sampling rate	524 s (4 Sa/s)

A total of 8 recording times are available, all separated by a factor of 2, i.e. 1, 2, 4, 8, 16, 33, 66, 131, 262 and 524 seconds.

The setting for *Waveform recording time* may affect the Irradiation time calculation. Make sure to set back the *Waveform recording time* to the lowest choice after temporarily modifying it. Please also note that in QABrowser, the waveforms are limited to between 0.32 and 4 seconds.

2.4.1.4 Typical Response, Piranha

The table below shows the typical response for the Piranha at standardised radiation qualities.

Radiography, Fluoroscopy, and Dental (measured using RTI RQ Code R1, W/Al)

Radiation quality		Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
PTB	ISO 4037 IEC 61267			HVL (mm Al)	Factor kQ (Rel. RQR 5)
DV40	RQR 2	26,38	2,49	1,42	1,0186
DV50	RQR 3	29,14	2,46	1,77	0,9794
DV60	RQR 4	32,14	2,68	2,19	0,9949
DV70	RQR 5	34,84	2,83	2,57	1
DV80	RQR 6	37,88	2,99	3,01	0,9976
DV90	RQR 7	41,1	3,18	3,48	0,9920
DV100	RQR 8	44,33	3,36	3,96	0,9920
DV120	RQR 9	50,86	3,73	5,00	0,9988
DV150	RQR 10	61,47	4,38	6,55	1,0199

Note: These values are typical values measured at PTB in Germany in 2007.

Radiation quality		Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
PTB	ISO 4037 IEC 61267			HVL (mm Al)	Factor kQ (Rel. RQR 5)
DH50	RQA 3	38,02	12,5	3,74	0,9997
DH60	RQA 4	45,02	18,7	5,32	1,0021
DH70	RQA 5	51,27	23,8	6,73	1
DH80	RQA 6	57,71	29,0	8,12	1,0325
DH90	RQA 7	63,27	33,2	9,21	1,0309
DH100	RQA 8	68,57	37,4	10,10	1,0296
DH120	RQA 9	78,83	43,7	11,59	1,0191
DH150	RQA 10	94,32	49,4	13,23	1,0072

Note: These values are typical values measured at PTB in Germany in 2009.

Mammography, Mo / 30 µm Mo and 30 µm Mo + 2 mm Al (measured using RTI RQ Code M1)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. RQR-M2)
MMV25	RQR-M1	14,89	0,28	0,9781
MMV28	RQR-M2	15,44	0,31	1
MMV30	RQR-M3	15,7	0,33	1,0073
MMV35	RQR-M4	16,28	0,37	1,0060
MMH25	RQA-M1	18,61	0,59	0,9840
MMH28	RQA-M2	19,27	0,63	0,9818
MMH30	RQA-M3	19,75	0,67	0,9744
MMH35	RQA-M4	20,96	0,75	0,9804

Note: These values are typical values measured at PTB in Germany in 2007.

Mammography, Mo / 1 mm Al (measured using RTI RQ Code M8)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. MAV28)
MAV25	-	17,58	0,48	1,0033
MAV28	-	18,29	0,54	1
MAV30	-	18,66	0,56	0,9978
MAV35	-	19,36	0,61	0,9944
MAV40	-	19,89	0,64	0,9915

Note: These values are typical values measured at PTB in Germany in 2009.

Mammography, Mo / 25 µm Rh (measured using RTI RQ Code M3)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. MRV28)
MRV25	-	15,78	0,34	0,9945
MRV28	-	16,29	0,38	1
MRV30	-	16,54	0,39	0,9980
MRV35	-	17,02	0,43	0,9911
MRV40	-	17,4	0,45	0,9852

Note: These values are typical values measured at PTB in Germany in 2009.

Mammography, Rh / 25 µm Rh (measured using RTI RQ Code M4)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. RRV28)
RRV25	-	15,57	0,32	1,0018
RRV28	-	16,34	0,37	1
RRV30	-	16,73	0,39	1,0036
RRV35	-	17,57	0,45	1,0089
RRV40	-	18,18	0,49	1,0081

Note: These values are typical values measured at PTB in Germany in 2009.

Mammography, W / 0.5 mm Al (measured using RTI RQ Code M7)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. WAV28)
WAV25	-	16,08	0,35	0,9924
WAV28	-	16,97	0,40	1
WAV30	-	17,49	0,43	0,9974
WAV35	-	18,73	0,51	0,9928
WAV40	-	19,79	0,58	1,0028

Note: These values are typical values measured at PTB in Germany in 2009.

Mammography, W / 50 µm Rh (measured using RTI RQ Code M6)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. WRV28)
WRV25	-	17,6	0,48	0,9978
WRV28	-	17,99	0,51	1
WRV30	-	18,19	0,52	1,0009
WRV35	-	18,78	0,56	0,9969
WRV40	-	19,54	0,61	0,9959

Note: These values are typical values measured at PTB in Germany in 2009.

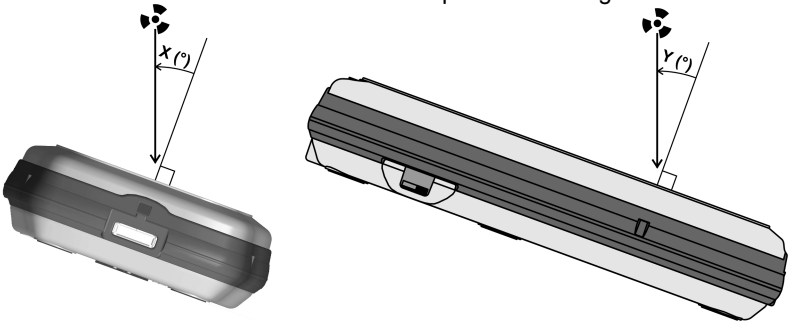
Mammography, W / 50 µm Ag (measured using RTI RQ Code M10)

Radiation quality		Mean energy air kerma (keV)	Air kerma measurement	
PTB	ISO 4037 IEC 61267		HVL (mm Al)	Factor kQ (Rel. WSV28)
WSV25	-	17,87	0,50	1,0108
WSV28	-	18,66	0,56	1
WSV30	-	18,92	0,58	0,9983
WSV35	-	19,57	0,63	0,9963
WSV40	-	20,22	0,68	0,9969

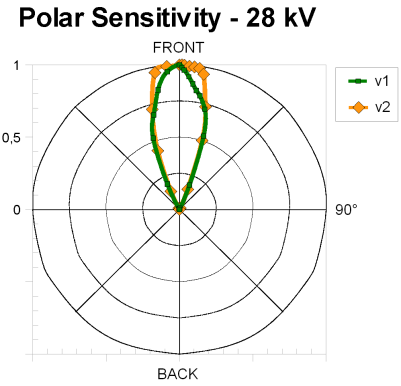
Note: These values are typical values measured at PTB in Germany in 2009.

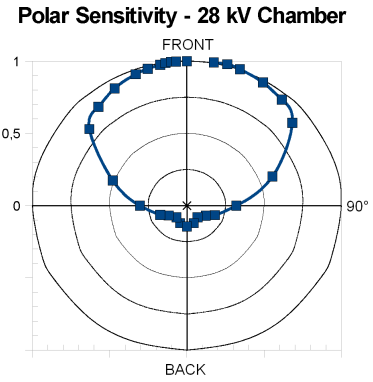
2.4.1.5 Angular Sensitivity, Piranha

In this section you can see graphs of the typical angular sensitivity for dose measured with the Piranha at 28 and 70 kV. The setup is shown in figures below.



This "directional" behaviour makes it excellent for reproducible measurements, with less influence by nearby spreading matter. This makes it possible to make accurate HVL measurements even when measuring with "bad geometry", which is especially interesting for mammography. To understand, please see the polar plot shown below. The Piranha is shown to the left, and a typical mammographic ion chamber to the right.

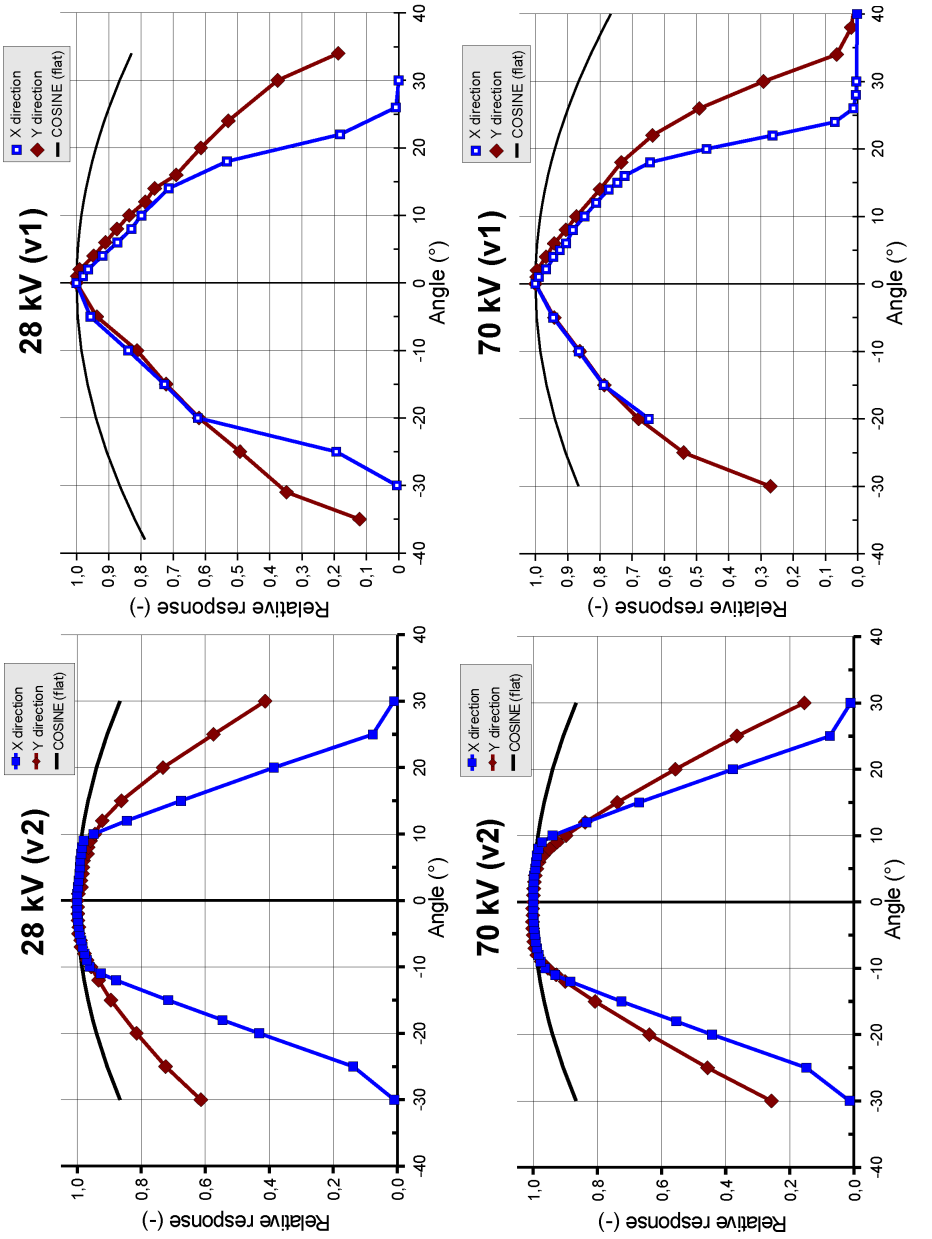




There are two different graphs, depending on the product version of your Piranha. The product version is the version number you can find on the label on the bottom of the Piranha. If the version of your Piranha is 1.X, use the graphs marked v1. For 2.X and higher use graphs marked v2.

Note! For v1.X it is however important that you place the detector surface perpendicular to the direction of the radiation source or that you make corrections according to the tables in section Corrections for Angular Sensitivity 56.

For radiography this is generally no problem, since most measurements are performed in the middle of the field, perpendicular to the incident radiation.


28 kV (v1)
70 kV (v1)
28 kV (v2)
70 kV (v2)
X direction
Y direction
COSINE (flat)
Relative response (-)
Angle (°)

2.4.2 Piranha External Probes

The inaccuracy is here defined as the root of the square sum of systematic errors, which has not been eliminated, and random errors (dispersion around a mean value). The calculation of the inaccuracy is based on 15 different measurements and with a confidence level of 95 %. Of the total inaccuracy, random error is 20 % and general inaccuracy is 80 %.
Note: Irradiation time is often called exposure time in daily use.

Reference conditions

Temperature	+18 °C to +23 °C
Relative humidity	50 %
Air pressure	101.3 kPa
Radiation quality **Radiography** **Mammography** **CT**	 70 kV, 2.5 mm Al 28 kV, 30 µm Mo 120 kV, 2.5 mm Al

Note: The reference conditions are given in reference to the IEC61674 standard.

General

Connector type	Hirose ST40X-10S with built-in detector identification.

Measuring range and inaccuracy

The detector noise given is typical values at room temperature.

- Piranha External Dose Probe (typical sensitivity +55 µC/Gy)

Parameter	Range	Inaccuracy	Typ. noise
Air kerma (Dose)	100 pGy – 1.5 kGy 12 nR – 170 kR	±5 % (for time > 0.1 ms)	
Air kerma rate (Dose rate) (5 s moving average)	 4 nGy/s – 150 mGy/s 460 nR/s – 16 R/s 26 µR/min – 1000 R/min 1.6 mR/h – 60 kR/h 1 nGy/s – 150 mGy/s	(valid for Irr. time >20 ms) ±5 % or ±1 nGy/s ±5 % or ±100 nR/s ±5 % or ±6 µR/min ±5 % or ±360 µR/h ±5 % or ±250 pGy/s	 ±500 pGy/s ±100 pGy/s
Irradiation time	0.1 ms – 34000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	Resolution 0.5 ms

Note 1: The air kerma rate is calculated as the air kerma divided by the time. See also Waveforms and Triggers 44.
Note 2: The standard calibration for the Piranha External Dose Probe is W/23 mm Al. This calibration was chosen since the main use of the detector is to measure the dose to the image intensifier, after the phantom. However, you can just as well use this probe for measurements of skin dose. The detector is very linear in its energy response and will not be affected by a different filtration.

Pulses

Parameter	Range
Dose/pulse	1 nGy/pulse - 3 kGy/pulse [1]
Pulse dose rate	Lower limit 10 µGy/s (70 mR/min), otherwise same as for air kerma rate.
Min. output peak doserate - High Sensitivity - Low Sensitivity	Doserate (min. pulse width) 0.23 µGy/s (4 ms) / 1.8 µGy/s (0.5 ms) 10 µGy/s (4 ms) / 73 µGy/s (0.5 ms)
Pulse rate - Normally	 0.5 – 100 Hz, resolution 0.5 Hz
Pulse width	4 ms - 2000 s
Duty cycle	5 - 95 %
Minimum pulse width	pulse width (min. peak doserate) 4 ms (0.23 µGy/s) / 0.5 ms (1.8 µGy/s)
Minimum ripple (pulse top to bottom)	50 %
Irradiation time	1 – 65535 pulses, resolution 1 pulse

Note 1: Max dose/pulse depends on the pulse length.

Waveform recording time

At max sampling rate	1024 ms (2 kSa/s)
At min sampling rate	524 s (4 Sa/s)

A total of 8 recording times are available, all separated by a factor of 2, i.e. 1, 2, 4, 8, 16, 33, 66, 131, 262 and 524 seconds.

Note! The setting for *Waveform recording time* may affect the Irradiation time calculation. Make sure to set back the *Waveform recording time* to the lowest choice after temporarily modifying it. Please also note that in QABrowser, the waveforms are limited to between 0.32 and 4 seconds.

The table below shows the typical response for the Piranha External Dose Probe at standardised radiation qualities.

Radiation quality		Mean energy air kerma (keV)	Total Filtration (mm Al)	Air kerma measurement	
PTB	ISO 4037 IEC 61267			HVL (mm Al)	Factor kQ (Rel. RQR 5)
DV40	RQR 2	26,38	2,49	1,42	1,087
DV50	RQR 3	29,0	2,46	1,77	1,044
DV60	RQR 4	32,0	2,68	2,19	1,013
DV70	RQR 5	34,8	2,83	2,57	1
DV80	RQR 6	37,8	2,99	3,01	0,993
DV90	RQR 7	41,0	3,18	3,48	0,988
DV100	RQR 8	44,2	3,36	3,96	0,986
DV120	RQR 9	50,8	3,73	5,00	0,986
DV150	RQR 10	61,2	4,38	6,55	1,002

Note: Note: These values are typical values measured at PTB in Germany in 2009.

- Piranha MAS-1 Probe, Invasive mAs probe (sensitivity 1 nC/mAs)

Module type	Range	Inaccuracy	Typ. noise
Tube charge	0.001 mAs –	±1 % (for time > 0.1 ms)	
Tube current	0.1 – 3000 mA	±1 % or ±10 µA (for time >100 ms)	±1.5 µA
Pulse tube current	Lower limit 1 mA, otherwise same as tube current.		
Time [1]	0.1 ms – 34000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	Resolution 0.5 ms

Note 1: When the Piranha internal detector is used simultaneously, the default mode of operation is to use the internal detector for time measurement.
Note 2: The tube current is calculated as the tube charge divided by the time. See also Waveforms and Triggers 44.

- Piranha MAS-2 Probe, Non-invasive mAs probe (sensitivity 1 nC/mAs)

Module type	Range	Inaccuracy	Typ. noise
Tube charge	0.1 mAs –	±5 % (for time > 0.1 ms)	
Tube current	10 – 4000 mA	±5 % or ±2 mA (for time > 20 ms) (±3 % at 250 mA)	±1 mA
Pulse tube current	Lower limit 50 mA, otherwise same as tube current.		
Time [1]	0.1 ms – 34000 s 1 – 65535 pulses	±1 % or ±0.5 ms ±1 pulse	Resolution 0.5 ms

Note 1: See also note 1 and 2 for the Piranha MAS-1.

- Piranha Light Probe, Light detector (typical sensitivity 670 pA/nit or 200 pA/lx)

Module type	Range	Inaccuracy	Typ. noise
Luminance **Illuminance**	0.003 – 72000 cd/m² 0.001 – 24000 lx	±5 % or ±0.6 mcd/m² ±5 % or ±0.2 mlx	±0.3 mcd/m² ±0.1 mlx

- CT-DP, CT Dose Profiler (typical sensitivity 3.6 µC/Gym)

Module type	Range	Inaccuracy	Typ. noise
Air kerma (Dose)	1,5 nGy – 22 kGy 160 nR – 2.5 MR	±5 % ±5 %	
Air kerma rate (Dose rate)	60 nGy/s – 1.1 Gy/s 6.8 µR/s – 125 R/s 0.4 mR/min – 7500 R/min 24 mR/h – 450 kR/h	±5 % or ±15 nGy/s ±5 % or ±1.6 µR/s ±5 % or ±0.1 mR/min ±5 % or ±6 mR/h	±8 nGy/s

2.5 Standards and Compliances

Hereafter you can find declarations of conformity, as well as documents describing the intended use of the Piranha system.

2.5.1 Waste Electrical and Electronic Equipment (WEEE)

The European Union Directive 2002/96/EC on Waste from Electrical and Electronic Equipment (WEEE) places an obligation on manufacturers, distributors, and retailers to take back electronics products at the end of their useful life.
The WEEE directive covers all RTI products being sold into the European Union (EU) as of August 13, 2005. Manufacturers, distributors, and retailers are obliged to finance the cost of recovery from municipal collection points, reuse, and recycling of specified percentages per the WEEE requirements.

Instructions for disposal of WEEE by Users in the European Union

The symbol, shown left, is marked on the product, which indicates that this product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of the user's waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For more information about where you can drop off your waste equipment for recycling, please contact your local distributor from whom you purchased the product.

2.5.2 Manufacturer's Declaration of Conformity

Declaration of Conformity

We, RTI Electronics AB, Göteborgsvägen 97 / 50, SE-431 37 MÖLNDAL, Sweden,

declare under our sole responsibility that the product:

Product name: Piranha **Model name:** 140 to 657

Type of equipment: kV- & Electrometer

Intended use of this product: See separate document no: 2-CE-9620000-0, "Intended use of the Barracuda"

is in conformity with the provisions of the following EC Directive(s):

- **89/336/EEC Electromagnetic Compatibility Directive** (EMC), and amending directives 92/31/EEC, 93/68/EEC, 98/13/EEC
- **73/23/EEC Low Voltage Directive** (LVD), and amending directive 93/68/EEC

and that the following standards and/or technical specifications referenced below have been applied:

EN 55022/B, EN 55014, EN 60950 part 5.2.2 and 5.2.3 (EN 60601-1-2 part 19), EN 61000-3-2, EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6, EN 61000-4-11, ETS 300 342-1

CE

Mölndal, 2006-07-12,

Lars Herrnsdorf, Vice President

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2-CE-9629001-0 Tillverkardeklaration Piranha.odt, Revision: A

2.5.3 Intended Use

Intended Use of the Barracuda and Piranha

Accessory to diagnostic X-ray equipment to be used as an electrometer. Together with external probes it is to be used for independent service and quality control, as well as measurements of kerma, kerma rate, kVp, tube current, exposure time, luminance, and illuminance within limitations stated below.

If installed according to accompanying documents, the product is intended to be used together with all diagnostic X-ray equipment except for:

- therapeutical X-ray sources.
- X-ray equipment with tube potential below 18 kV.
- X-ray equipment on which the instrument cannot be mounted properly, e.g. equipment where the beam field size is narrower than the active part of the detector.
- specific types of X-ray equipment listed in the instructions for use or in additional information from the manufacturer.

With the X-ray installation in stand-by conditions without patients present the product is intended to be used:

- to provide the operator with information on radiation beam parameters that might influence further steps in an examination but not an ongoing exposure.
- for assessing the performance of the X-ray equipment.
- for evaluation of examination techniques and procedures.
- for service and maintenance measurements.
- for quality control measurements.
- for educational purposes, authority supervision etc.

The product is intended to be used by hospital physicists, X-ray engineers, manufacturer's service teams, and other professionals with similar tasks and competencies. The operator needs a short training to be able to use the product as intended. This training can be achieved either by careful study of the manual, studies of the built-in help function in measurement software, or in a short course ordered from the manufacturer.

The product is intended to be used inside X-ray rooms ready for clinical use and can safely be left switched on and in any measuring mode in the vicinity of patients.

The product is **NOT** intended to be used:

- for direct control of diagnostic X-ray equipment performance during irradiation of a patient.
- so that patients or other unqualified persons can change settings of operating parameters during and immediately before and after measurements.

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Phone: +46 (0)31 746 36 00 • Fax: +46 (0)31 27 05 73 • E-mail: info@rti.se • Web: www.rti.se

2-CE-9620000-0 Avsedd användning Barracuda.odt, version 1.3/2006-06

2.5.4 FCC Certification

Piranhas of product version 3.1 and newer contains FCC certified transmitter module (Bluetooth).

FCC ID R47F2M03GX
This device has been tested and found to comply with the limits for a Class-B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used according with the instruction manual, may cause harmful interference to radio communication. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

2.6 Maintenance

2.6.1 Updating the Piranha Firmware

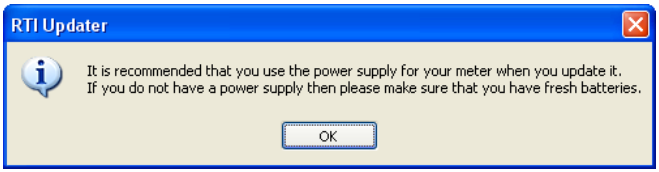
All firmware that is controlling the function of the Piranha is stored in flash memory to allow quick and easy update. The RTI Updater with the latest firmware is always available free of charge on the RTI Electronics Web site at http://www.rti.se. To update your Piranha you must first download the latest version and install it on a PC. The PC needs to have an USB port.

Note!
You will need to have access to an administrative account to install the software.
To update the Piranha firmware (or bootloader):

1. First download the latest version of the RTI Updater Setup from RTI Electronics Web site.

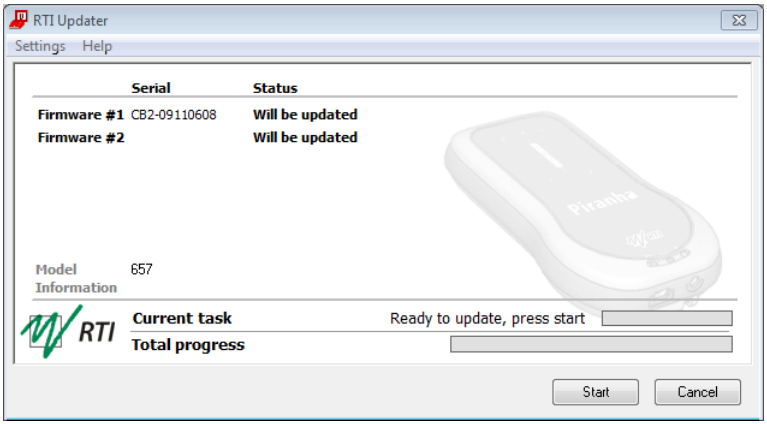
2. Unzip the file and run the file "RTI Updater Setup.exe" to install it on your PC. In the end of the installation process you will get the question if you want to run that updater immediately. If you have your Piranha available you can connect it as described in step #3. Answer "Yes" and continue with step #6.

3. Connect the Piranha. Use the USB cable that came with your Piranha to connect your Piranha to one of the USB ports on the PC. Power on the Piranha. Use the power supply to ensure that no power failure occur during the update process. If you do not have a power supply available, make sure you have fresh batteries in the Piranha. You will get a notice about that.


RTI Updater
It is recommended that you use the power supply for your meter when you update it.
If you do not have a power supply then please make sure that you have fresh batteries.
OK

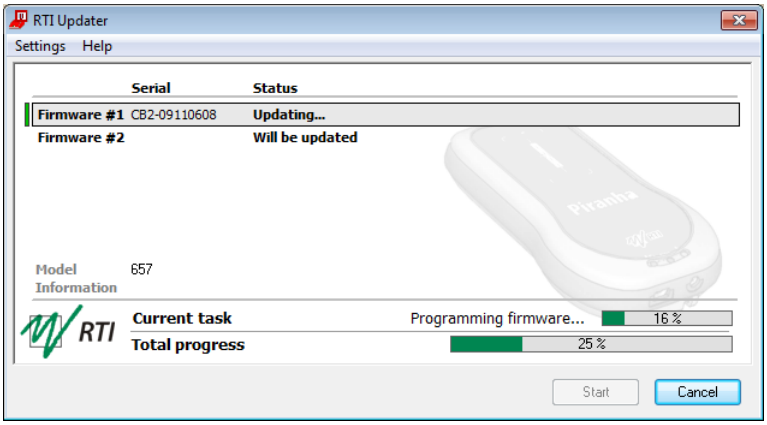
4. Go to **Start Menu | RTI Electronics | RTI Updater** and select the RTI Updater.

5. The RTI Updater starts and locates the Piranha automatically if it is connected to an USB port.



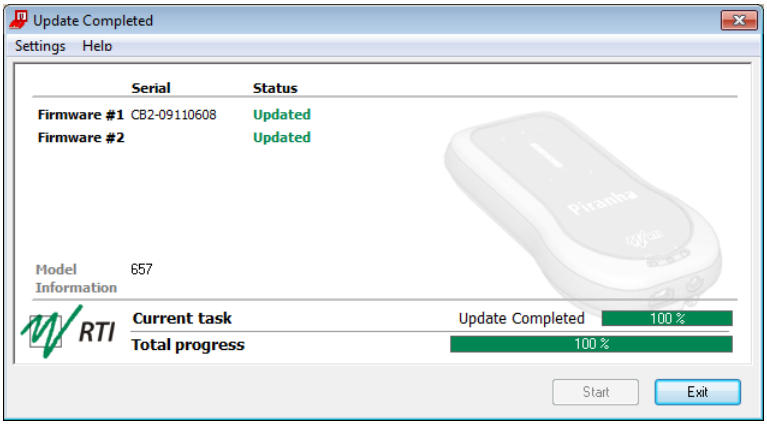
6. If the Piranha is found, the window in the figure above is shown. The different modules are checked and after a while the start button is enabled. Click **Start**. If the Piranha cannot be found, a message with suggested solutions is shown.

7. The updating process starts. The RTI Updater checks the current versions and compares with the update. Modules with old firmware are automatically updated.



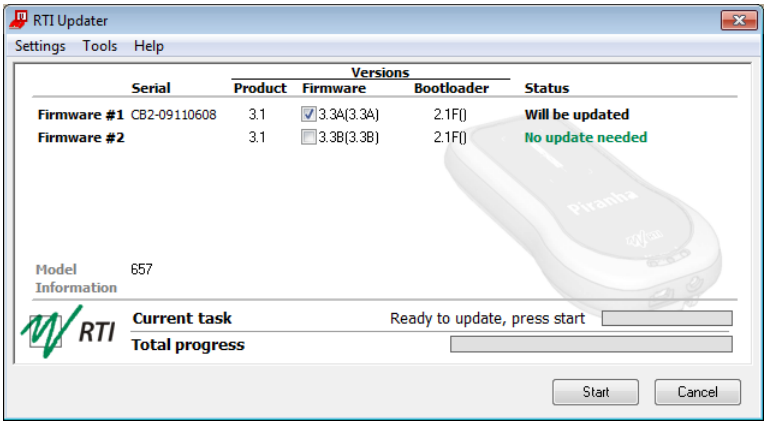
8. Note that storing the new firmware in the flash memory may take several minutes for each module. The RTI Updater will indicate which modules have been updated.

9. Power off the Piranha and disconnect the serial cable when the program indicates that everything is OK.



If you have any problem with your Piranha after updating, re-install the firmware again before contacting your local distributor or RTI Electronics. To re-install firmware repeat step 1 to 9 above, but before performing step #6 go to the menu **Settings** and select **Always Overwrite**.

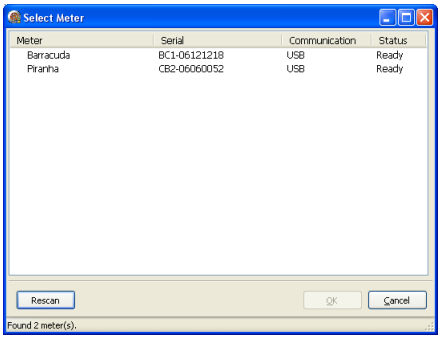
Note! If you want to see more details of what is updated, use the menu **Settings - Advanced**, and you will see more information as shown in the figure below.



Note! You normally also need to update the QABrowser and Ocean, when you update the firmware. See section Updating the QABrowser and the Ocean manual for details.

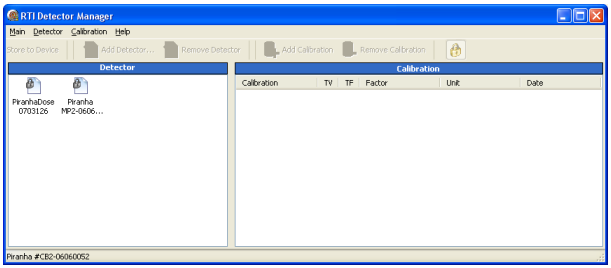
2.6.2 Managing Detector Calibrations

RTI Detector Manager is a special Windows software that gives an overview of all calibrations for the detectors and probes in your system. You will find the RTI Detector Manager on your Product CD, in the folder **\Software\RTI Detector Manager\.**,Start the file **RTI Detector Manager.exe** by double-clicking it.

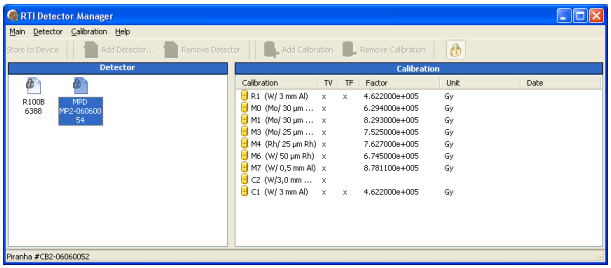


Select the instrument of interest (Piranha) and click **OK**.

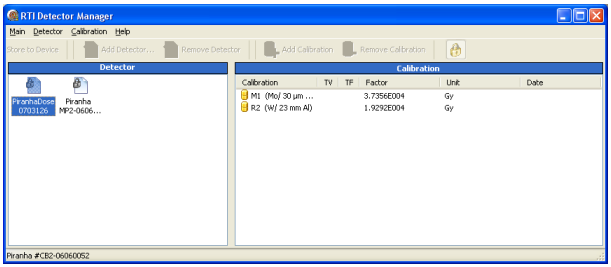
If no instrument appears, check the communication cable and that the Piranha is powered on, then click **Rescan**.



Next, the available detectors are shown to the left. The Internal detector is always available, but external probes will only show up if they are attached.



When clicking a detector, the available calibrations will show up to the right (In this case the Internal detector is highlighted). The TV and TF columns show an **×** if there are calibrations for Tube Voltage and/or Total Filtration. The factor column shows the calibration factor (for dose in this case).



Here is another example (Piranha Dose Probe). This type of detector only contains a calibration factor for dose.

2.7 Measurement Settings

2.7.1 Settings - Conditions

Here general conditions for the measurements are shown. Different values can be shown depending on selected measured parameter.

Conditions - TF and Waveform

Total Filtr. Shows actual total filtration value. *Estimate* means that a new estimation will be performed at next exposure and the values will be displayed on screen.

Waveform Shows the actual waveform type. Determine means that a new analyse of the waveform will be performed for the next exposure. The result will be displayed on screen. The waveform types supported are:

- *DC/HF*
- *Single Phase*
- *3-Phase 6-Pulse*
- *3-Phase 12-Pulse*
- *AMX-4*
- *Pulsed*

The first four can be automatically determined when *Estimate* is chosen. The selected or set waveform is also shown with a symbol on the Real-Time Display, see Indicators and Symbols.

Note! In Ocean using Quick-Check you need to select the generator waveform type for each measurement session. Default is *HF/ Constant potential*.

AMX-4

The difficulties when measuring tube voltage on a GE AMX-4 is a well-known problem. Due to high kV ripple at a frequency of 2 kHz it is hard for most non-invasive kVp-meters to follow the kV waveform correctly.

This waveform type has an agreement with measurements made with the Keithley Triad System 37946C mobile filter pack (50-135 kV), which is the only filter package recommended by GE. According to GE, the use of the standard Keithley 37617C W-R filter pack (50-150 kV) is not good enough. The results have further been verified with measurements with a traceable high voltage divider that has sufficient bandwidth to accurately follow the kV ripple from the AMX-4.
Therefore it is important to select the **AMX-4** waveform(under **Settings | Conditions**). More about the AMX-4 correction can be found in the Application Note 1-AN-52020-1 from RTI Electronics AB.

Pulsed

This waveform type should be used for pulsed fluoroscopy especially when the pulses do not have a "good" square waveform shape. The exposure time must be longer than the selected recording time when using this waveform type. (Pulsed waveform type is selected under **Settings | Conditions** in the same way as the AMX-4 waveform type.)

Conditions - TP-factor

If an ion chamber is used, temperature and pressure can be specified to get correct dose measurements.

Note! The Internal detector and other semiconductor detectors are virtually not affected by temperature and pressure.

The **TP Factor** is calculated as follows:

$$TP = P_0/P \times T/T_0$$

where: P_0 and T_0 are the reference air pressure and absolute air temperature (normally P_0=101.3 kPa and T_0=293 K [20 °C])
T and P are the actual absolute air temperature and pressure in the same units (kPa and K)

Temperature This value is used to calculate the TP-factor when ion chambers are used. Temperature can be specified in Kelvin, degrees Celsius, or degrees Fahrenheit. Unit is chosen in the QABrowser Setup, under Units.

Pressure This value is used to calculate the TP-factor when ion chambers are used. Air pressure can be specified in several different units. Unit is chosen in the QABrowser Setup, under Units.

Please note that the pressure easily changes by 10 %. For the same effect from temperature, it must change 30 °C (or 54 °F).

Pulse rate

If a pulsed mode is used, like pulsed fluoroscopy or pulsed radiography (cine) the pulse rate can be specified in pulses per second (same as Hz). This allows you to get a dose/pulse reading even if the detector used (e.g. ion chamber) is too slow for the Piranha electrometer to detect the pulses. A solid-state detector, like the Piranha Dose Probe, is however fast enough to detect the frequency even for very low-level signals.

Compression paddle

For mammography, it is sometimes easier to do measurements with the compression paddle in the field. The compression paddle will however affect the Piranha kV and dose reading. With this setting, all the measured values (kV, dose and HVL) will be corrected

according to what the user has selected.
When selected you will see the settings for *Scatter factor* and *Equivalent thickness*. The thickness is given in "mm Al". If you do not know, ask the manufacturer or make a comparison with Aluminium filters.

Scatter factor If an ion chamber is positioned just below the compression paddle, the measured dose will rise, because of side scattering from the compression paddle material. The effect of this is depending on the ion chambers angular dependence. Since the Piranha is almost insensitive to this, you can put a number here to compare readings from the Piranha with readings from an ion chamber. See also section Average Glandular Dose, AGD (MGD) 57.

Equiv. thickness The given equivalent compression paddle thickness is used to increase the accuracy of dose measurements when dose is measured below the compression paddle. It is given in equivalent thickness of aluminium.

Note! This feature can also be used if you have additional filtration in the beam. Add the equivalent thickness of aluminium.

Beam Correction Sometimes you may want to make comparable measurements with known mechanical setup. For instance if you want to emulate ion chamber measurements in a particular scattering situation. Then you can set a *Beam Correction factor* to get that reading. In this case the ion chamber measures an extra 25 % from side and back-scatter. Using this factor makes the readings to be the same. It is of course important that the mechanical setup in these cases are the same.

2.7.2 Settings - Piranha

Here general measurement settings for the Piranha are shown.

Post Delay The post delay time defines how long time the Piranha shall wait and "look for more" after detecting what can be considered to be "the end of the exposure". Default value is 250 ms. The post-delay is necessary when measuring on units with some kind of pre-pulse or for pulsed exposures.

Trig source This setting makes it possible to define the trig source for the electrometer module.
Available settings are:

- *Individually*, each detector starts to measure individually when it detects a signal.
- *Internal detector*, the measurement of all parameters (all modules) start when the Internal detector starts to measure.

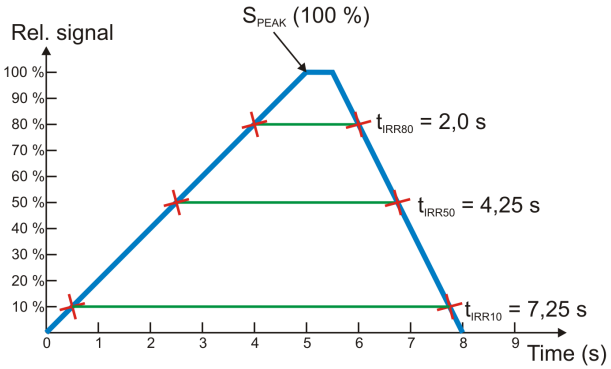
Default value is always Internal detector when it is used. This is the recommended trig source.

Trig level (time) Here you can set the level used for irradiation time measurements.

"Trig level (time)" (TL) is normally set to 50 % of the peak waveform (SPEAK), but can be set between 10 and 90 %. The irradiation time is then calculated as the end time minus the start time.

- The start time is the first time the signal goes above $TL \times S_{PEAK}$.
- The end time is the last time the signal goes below $TL \times S_{PEAK}$.

See example below.



Update

This setting defines when Piranha shall send measured values to the QABrowser.
Four different alternatives are available:

- *After exp.*, the display/software receives a new value when the exposure terminates.
- *Continuous*, the Piranha is continuously sending data as long as radiation is detected. Values to the display/software are updated about every four seconds. Typically used for Fluoroscopy.
- *Timed*, the user sets a measurement time. The user then starts the measurement and the Piranha will measure all radiation received during the measurement time, without any trig levels. When the time has passed, a reading will be presented.
- *Free run*, the Piranha will continuously measure the radiation without any trig levels.

Default value is set according to selected type of measurement and this parameter normally never needs to be manually changed, unless really low-level measurements are to be accomplished.

Waveform rec. time

The Piranha can sample a maximum of 2048 samples. Ocean supports the full depth, but the QABrowser is only able to show a total of 640 samples. The sampling interval is normally 0.5 ms, giving a total measurement window of 1024 ms in Ocean and 320 ms when using the QABrowser. By increasing the sampling interval, a much longer sampling window can however be selected. This is

very handy when longer exposure times are used and the waveforms need to be viewed.

Start after delay When this is selected, the waveform recoding will start after the set delay. This can be useful if you want to study a phenomenon that occurs after the normal waveform recording time. When this is selected the electrometer waveform will not show simultaneously and you will get a warning that the irradiation time measurement is inaccurate. The reason for this is that the Piranha needs the waveform from start to be able to accurately calculate the irradiation time.

2.7.3 Settings - Internal detector

Here general measurement settings for the Internal detector are shown. You can find information about the different parameters below.

Sensitivity Dose/TF This is used to set the dose and TF sensitivity for the Internal detector.
The sensitivity can be set to: Low, High, and Very High.

Sensitivity kV This is used to set the kV sensitivity for the Internal detector.
The sensitivity can be set to: Low and High.

Delay The delay time defines how long time the Piranha shall wait before starting to measure kVp after that radiation has been detected.

Window This gives the possibility to define a fixed time that Piranha measures kVp after that the delay time has expired. Default value is always "Infinite".

2.7.4 Settings - Other Detectors

Sensitivity This is used to set the sensitivity for the electrometer module. The sensitivity can be set to: *Low* and *High*.

Threshold This is used to set the trig level. It can be set to *Low (½×)*, *Normal, 2×*, *4×*, and *8×*. The default value is "Normal". The setting "Low" can be used if low signals are measured and a lower trig level is required. However, the risk for false triggering increases when "Low" is used. To avoid false triggering in a noisy environment use one of the "higher" threshold levels.

Normalize to distance Note: Only for dose detectors!
If *Normalize to distance* is checked, you have the option to normalize the dose reading to any given distance. Here you can enter your Source to Detector Distance (SDD) and a normalizing distance (SDD Norm), that you want the dose normalized to. When this is activated an "N" symbol will show on the RTD screen.

Chapter 3

Measurement Principles & Theory

3 Measurement Principles & Theory

The QABrowser has a number of measurement algorithms and applications built-in. This section describes some about the principles, how some values are calculated, and the basic use of such measurements.

3.1 Overview of Capability for Measurement Modes

The following graph shows an overview of some common capabilities the different X-ray measurement types have in the QABrowser.

Modality	HVL Application	Estimated TF	Quick-HVL
Radiography	OK	OK	OK
Cine/Pulsed exposure	OK	OK	OK
Fluoroscopy	OK	OK	OK
Pulsed Fluoroscopy	OK	OK	OK
Mammography	OK	–	OK
CT	–	OK	OK
Dental	OK	OK	OK
Panoramic Dental (OPG)	OK	OK	OK

3.2 Update Modes

The following four update modes are available:

- **After exp.**, the QABrowser receives a new value when the exposure terminates. This means when the output goes under the trig level and stays there at least the time set by Post Delay under *Settings* | *Piranha*. Reset time is one second.
- **Continuous**, the Piranha is continuously sending data as long as radiation is detected. Displays in the QABrowser are updated about every four seconds. Typically used for Fluoroscopy. Reset time is one second.
- **Timed**, the user sets a measurement time. The user then starts the measurement and the Piranha will measure all radiation received during the measurement time, without any trig levels or background compensation. When the time has passed, a reading will be presented. It has a long reset time for increased accuracy, which varies with the sensitivity, as seen in the table below.
- **Free run**, the Piranha will continuously measure the radiation without any trig levels or background compensations. No applications are available when using this mode. The mode has a feature called moving average which calculates the average of the measured values during a defined time, to increase accuracy by lowering the time resolution. This function gives a larger stability to the measurements. Free run also has a long reset time for increased accuracy, see the table below.

Note! In Ocean the **Normal Mode** automatically handles **After exp.** and **Continuous** modes.

Default value is set according to selected type of measurement and this parameter normally never needs to be manually changed, unless really low-level measurements are to be accomplished.

However, to measure on real low-level signals the *Timed* or *Free run* update mode may be used

Update mode	Auto reset	Reset time (s)	Sample time (ms)	Min. WF rec. time (s)	Max. WF rec. time (s)
After Exposure	–	1	0.5-64	0.32	40
Timed (Low/High sens.)	–	4	0.5-64	0.32	40
Timed (Very High sens.)	–	30	20-2560	13	2000
Continuous	Yes	1	0.5-64	0.32	40
Free run (Low/High sens.)	–	4	0.5-64	0.32	40
Free run (Very High sens.)	–	30	20-2560	13	2000

Note: The *Sample time* is the "resolution" of the waveform, i.e. time between two samples.

Auto reset means that a reset is performed after each trig off.
Reset time is the time it takes to perform a reset each time you hit *Reset*.
Sample time is the time between individual data point of the waveform.
Waveform recording time is the range of user selectable recording times the Piranha allows.

Note that in *Timed* and *Free run* you may get negative readings, for instance if you press reset when a signal is present on the detector.

3.2.1 Using Timed Update Mode

The Timed mode can be very useful both for very low dose rate measurements as well as for long duration measurements.

- For extreme low-level dose measurements you can improve your reading by subtracting the background level. First do a Timed measurement without exposing the detector to radiation and then do the same with radiation. The timed mode will use the same measuring time and the first reading can be subtracted from the first. Just make sure not to do a **Reset** between these measurements, as the **Reset** will also make an offset adjustment. Note also that low-level readings may give inaccurate kV readings.
- For long duration measurements, cases with slowly rising and falling output, or cases with very low pulse rate, timed mode may also be useful. For instance on CT machines where the rotation cannot be stopped.

3.2.2 Using Free Run Update Mode

Free run update mode works almost exactly as the ordinary *Continuous* update mode. There are however two differences:
1. Since there is no trig level, you will be able to measure lower, but there will be no time reading unless the signal goes over the trig level.
2. You can select a moving average function. This lets you set a time for moving average, this time acts as a averaging window, moving through time.

Moving average
This function is intended for low level dose rate measurements where increased sensitivity and stability is needed. The function uses a moving average algorithm where the number of seconds is selected by the user.

During the reset process the user must make sure that the detector is not exposed to radiation. After the reset procedure the Piranha will start to show a value calculated as the sum of the last X values divided by X (X is the number of seconds chosen by the user). For each new second that passes the last value in the stack will be discarded and a new value added. This means of course that it will take X seconds before the Piranha starts to show a valid value when the detector attached is exposed to a steady radiation level. In the same way it will take X seconds for the Piranha to show a zero value after the radiation has ended. Great care must be taken into choosing a time constant fitted to the nature of the signal.

Example
If you set the time to 8 seconds, each reading, will be the mean of the reading of the last 8 seconds. This means that it will take 8 seconds until the reading reaches a started set radiation level.

3.3 Display Messages and Active Messages

Even though the range of the Piranha measurement system is quite wide, sometimes the signal may get too low or too high. To inform you of this, there are display messages. These are mainly of two types, Active or Passive. Active messages are shown when the hardware settings can be adjusted to adapt the measurement ranges. The active message will just inform you that it is making an automatic adjustment and you can simply do another exposure/measurement. The active messages can be disabled, see the following section.

The passive display messages indicate what the problem is and possible remedies for them. These will show if there are no active messages, the active messages are disabled, or when no more automatic adjustment can be done.

3.3.1 Active Messages

In some rare occasions it might be helpful to disable the active messages, for instance if the detector signal is very noisy or there are pre-pulses that makes the system auto-adjust erroneously.

Below the various active messages are shown. Make sure to follow the text shown, since reset may be performed automatically. Otherwise do a **Reset** again.

High signal	One or several detectors have too high signal.
Low signal	The Piranha detects a signal but it is too low to present a reliable result.
High kVp	Measured tube voltage is higher than that of the selected kV-range.
Low kVp	Measured tube voltage is lower than that of the selected kV-range.

3.3.2 Display Messages

High signal
One or several detectors have too high signal.
- Lower the set sensitivity under settings.
- Reduce the mA and/or increase the distance from tube to detector.

Exp. < Delay
The exposure time is too short compared to the delay time.
- Increase the exposure time and/or reduce the values of delay and/or window time.

Keep in mind that the type of measurement sets the delay time value. The standard value for radiography use is 5 ms, but for dental it is 200 ms. See Measurement Type Settings.

High kVp
Measured tube voltage is higher than that of the selected kV-range.
- Change to a higher kV-range.

Low kVp
Measured tube voltage is lower than that of the selected kV-range.
- Change to a lower kV-range.

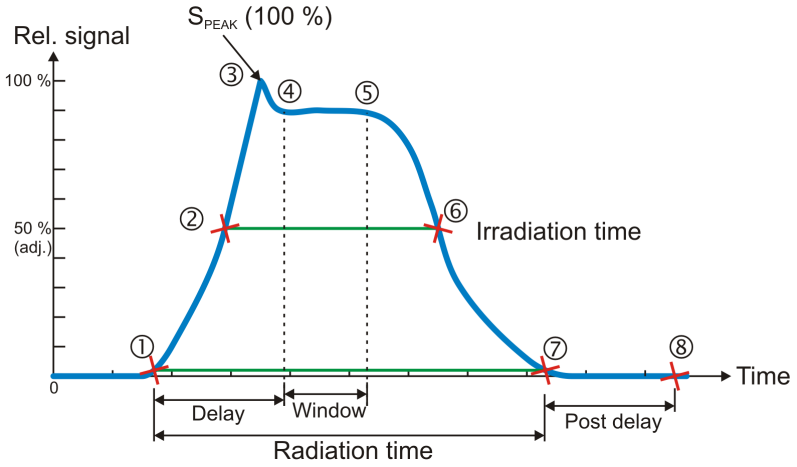
Low Signal
The Piranha detects a signal but it is too low to present a reliable result.
- Increase the mA and/or decrease the distance from X-ray tube to detector or change the sensitivity for the dose parameter to *High sensitivity* or even *Very High sensitivity*. Also the *kV sensitivity* can be changed. You find these settings if you tap the ⓘ symbol.

Reposition Detector
The radiation signal on D2 and D1 is not within 5 % (quota not between 0.95 to 1.05). The most common reason for this is that the detector area is only partially irradiated, the detector is tilted, or the filtration differs between D2 and D1 (e.g. heel effect).
- Change the field size or move the detector into the central beam.

Negative Signal
The electrometer module detects a negative signal.
- Most common is that the mAs-probe have been connected in the opposite direction on the HV cable. Change the polarity of the current probe.
- Also small negative drift created from the detector source, typically initially after reset can give this message. Special care should be taken when using ionization chambers, since it may take a few minutes before the initial drift of the electrometer and detector has stabilized.
- Do a **Reset** to clear the message.
- This message does not appear in the *Timed* and *Free run* update modes.

3.4 Waveforms and Triggers

To get an understanding of how triggers, delays, and windows work, take a look at the waveform below. This is what happens during a standard exposure:



1. The radiation starts, i.e. it goes over the detector's lowest trig level.
2. The signal reaches 50 % of its maximum. This is the starting point for the irradiation time calculation. (The level is user adjustable.)
3. The signal reaches its maximum.
4. The *Delay* time is reached. (User adjustable.) kV integration window starts.
5. The *Delay+Window* time is reached. (User adjustable.) kV integration window stops.
6. The signal goes below 50 % of its maximum. This is the end point for the Irradiation time calculation. (The level is user adjustable.)
7. The radiation ends, i.e. it goes under the detector's lowest trig level.
8. If the signal has been below the trig level during all of *Post delay*, the exposure is considered finished. All exposure readings are calculated.

Integrated signal (dose, mAs, etc.)
Is the integration of all signal which means the area below the curve above from point 1 to 7. During the measurement (exposure) the accumulated signal (dose, etc) is displayed where applicable.

Signal rate (dose rate, tube current, etc.)
During the measurement the mean signal for the last second is displayed. When the measurement (exposure) is over, point 8 above, the mean signal for the whole measurement is displayed. This signal rate is calculated as all integrated signal (as described above) divided by the irradiation time. If no irradiation time is possible to calculate, the radiation time is used instead.
This means that for long measurements you may see a change in the rate value (dose rate, etc) when the measurement is finished, if the signal level was changed during the measurement.

3.5 Measurement Principle for the Piranha

The following are the key features of the Piranha design:

- Small size
- Optimized filter packages for five different kV ranges
- Very sensitive and wide dynamic range
- Check filter for measurement geometry verification
- Single exposure estimation of total filtration and Quick-HVL
- Single exposure estimation of generator waveform type

The design of the detector package is very important to be able to measure kV and dose correctly in the whole range of 20 to 155 kV.
The Piranha design makes it possible to measure small field sizes, less than 3 mm width, and low output levels down to approximately 1 µGy/s. Basically the detector packages consist of four separate electrometer channels connected to detectors D1, D2, D3, and D4 and a moveable filter package that can change to one of six positions, each a combination of different filters for the detectors. One of these positions is used as a "check-filter". It has the same filter thicknesses for both D1 and D2. When the detector is perfectly positioned and both detectors have the same radiation the ratio between the two signals should thus be exactly "1.000". This is very useful information, and testing this makes sure that your measurement geometry is fine, giving reproducible readings. The other 5 filter pairs have different thicknesses all optimized for different ranges of the tube voltage; two (1 and 2) are used for the low mammography energy range 20 to 45 kV, and three filters (3 - 5) are used for the radiography range 35 to 155 kV (35 - 75, 55 - 105, and 80 - 155 kV).

Using these four signals S1-S4 (from detectors D1 to D4) the Piranha can accurately calculate the corresponding tube voltage. The signal S3 is not affected by the moveable filters and is designed to measure the dose. This detector is marked by a square inside the rectangular detector area on the top panel. The reference depth for the sensitive area of the dose detector is 10 mm under the Piranha top panel surface.
The detector D4 is placed directly under D3 with additional filter in between. The ratio between S3 and S4 is used to estimate the total filtration for the radiography range. Using these signals together more accurate dose and tube voltage readings can be obtained.

Since all signals is measured simultaneously and with a relative high speed, the Piranha can thus automatically compensate the kV and dose for the dependence of the waveform and inherent/added tube filtration.

Chapter 4

Measurements with the Piranha System

4 Measurements with the Piranha System

4.1 Introduction

The Piranha system can, depending on model, measure up to eight parameters simultaneously plus three waveforms from a single exposure:

- kVp
- Dose and dose rate
- Exposure time
- HVL
- Estimated total filtration and determined waveform type
- mAs and mA
- pulses
- kV waveform
- Dose rate waveform
- mA waveform
- various pulsed fluoroscopy parameters

4.2 Radiography

Measuring the kVp on a radiographic units is straightforward since the Piranha can automatically detect and compensate for variation in the radiation quality. It is also easy to check that the detector area is fully and uniformly irradiated. Practically this means that the kVp value can be measured in the range 1.0 to 50 mm of total filtration. Therefore the Piranha can be placed in the beam wherever you want, as long as it passes the *Position Check*. It also has a very wide dynamic range so it very rarely happens that the signal level is not enough to get a correct kVp value. The radiography kV range is 35 to 155 kV.The displayed dose value has no energy dependence since it is automatically compensated for each exposure since both the kV, estimated filtration, and the waveform are measured.

4.2.1 kVp, Time, Dose, and Dose Rate

To measure on radiographic units:

1. Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha 10.

2. Place the detector on the table at the distance that is clinically relevant.

   Place the Piranha in the direction indicated in the figure below. Adjust the collimator so the radiation clearly covers the detector rectangle marked on the Piranha top panel, but try to keep the field size inside the top panel size to minimize scatter. Recommended field size is 20×40 mm. Furthermore the Piranhasurface should optimally be placed perpendicular to the focal spot, see also Angular Sensitivity, Piranha 22

3. It is recommended to make a check measurement at 70 kV to confirm that the detector area is uniformly radiated.
   The Piranha automatically changes back to the previous selected kV range.

4. Set kVp and mAs (or mA/time) to the desired values.

5. Make an exposure.

6. Read the values.

4.2.2 Dose Measurements with Piranha Dose Probe

1. Place the Piranha Dose Probe in the field and connect the cable to the Piranha input.

2. Set kVp and mAs (or mA/time) to the desired values.

3. Make an exposure.

4. Read the values.

4.2.3 Quick-HVL and Total Filtration

Total filtration

The estimated Total filtration is measured with the Piranha internal detector, in one exposure, simultaneously with all other parameters.
The estimated Total filtration is also in use for internal compensation of kV and dose values.

Quick-HVL

The Quick-HVL is measured with the Piranha internal detector, in one exposure, simultaneously with all other parameters.

4.3 Cine/Pulsed Radiography

For under-table cine measurement turn the Piranha upside-down.
The *Position Check* should be used to confirm the position. To be able to protect the image intensifier from the relative high output cine pulses a lead apron can be placed over the image intensifier input screen. The Piranha automatically measures the number of pulses based on information from the radiation waveform. It uses a 50 % trig level based on the maximum signal level.

4.3.1 kVp, Time, Dose, and Dose Rate

Use the same procedure as for the normal radiography measurement.
Note that if it is difficult to get a good pulse rate reading, you may use a manual pulse rate setting, as described under Measurement Settings 34 to get a dose per pulse reading.

4.3.2 Pulse Measurements with Piranha Dose Probe

Use the same procedure as for the normal radiography measurement. Note that if it is difficult to get a good pulse rate reading, you may use a manual pulse rate setting, as described under Settings to get a dose per pulse reading.

4.3.3 HVL, Quick-HVL, and Total Filtration

Use the same procedure as for the normal radiography measurement.
Note that if it is difficult to get a good pulse rate reading, you may use a manual pulse rate setting, as described under Settings to get a dose per pulse reading.

4.4 Fluoroscopy and Pulsed Fluoroscopy

For under-table fluoro measurement turn the Piranha upside-down. Use the optional detector rod to be able to put the detector in the cassette holder or on the image intensifier without risk of hazardous X-ray.

The *Position Check* should be used to confirm the position of the Piranha. When you select fluoroscopy or pulsed fluoroscopy (as type of measurement) the Piranha system automatically changes to continuously updating the display and using the highest possible sensitivity.

If dose rate or image intensifier dose rate is selected the Piranha or external Dose Probe can be used.

Normally the external Dose Probe is used to be able to measure the lowest possible dose rate levels down to 0.1 µGy/s. Another reason to use the external Dose Probe is that the detector is much smaller than the Piranha making it easier to position in front of the image intensifier without affecting the measuring field for the mA feedback loop.

If the image intensifier manually can control the mA and kV, then you can use the Piranha for measurements down to about 0.7 µGy/s. For pulsed fluoroscopy even lower levels can be measured.

As a secondary parameter the total dose is accumulated. After you have turned off the fluoroscopy unit, this value is used to calculate the average dose rate as total dose divided by the exposure time.

Note that for very low dose rate values the exposure time cannot be measured accurately and the last dose rate value cannot be stored automatically in the display. Then tap **Hold** to "freeze" the current value in the display. The waveform is also acquired when you tap **Hold**. Waveform is also automatically acquired when the selected delay time expires.

Select "I.I. input dose rate" as measuring parameter to be able to measure lowest possible dose rate and tap **Hold** to "freeze" current value in the display. The total accumulated dose is shoved after you have switched off the fluoroscopy unit.

4.4.1 Image Intensifier Input Dose Rate

Use patient equivalent phantom to measure the image intensifier input dose rate according to manufacturer's specification:

1. Place the Piranha Dose Probe in front of the image intensifier but outside the measuring field for the mA feedback loop. You may use the optional detector rod that can be attached to Piranha Dose Probe to position the detector without risk for hazardous X-ray exposure. Observe the image on the monitor.

Note! Since the external dose probe (Piranha Dose Probe) is not sensitive to back scatter, a lower value compared to a transmission ion chamber is typically detected (typically in the range of 5 - 20 %).

Tip! You may use the *beam correction factor* to make automatic corrections. The *beam correction factor* may also be stored permanently in a *Favourite* for easy access.

2. Start the fluoroscopy.

3. The image intensifier input dose rate is measured and the display is updated approximately every four seconds. Click **Hold** to "freeze" the currently shown value in the display. The waveform is also acquired when Hold is activated. Release Pause/ Hold, the display will continue updating the display continuously.

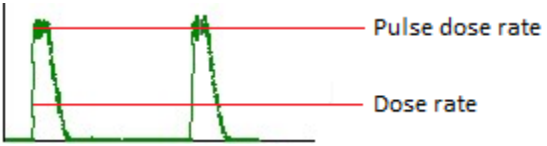
4. Stop the fluoroscopy.

5. Read the values.

4.4.2 Pulsed Fluoroscopy

Select type of measurement in similar way as for normal continuously fluoroscopy to setup the system.

Piranha is set-up for this application to calculate the number of pulses per second (Hz or pps), the dose/pulse, and pulse dose rate. The picture below explain the difference between the pulse dose rate and the traditional dose rate.



(Note that for DC waveform, pulse dose rate and dose rate gives the same value.)

When measuring tube voltage on pulsed fluoroscopy there is an additional waveform type available. This waveform type is called *pulsed* and is recommended for pulsed fluoroscopy measurements, especially if the pulses are not square wave shaped, since this can result in low tube voltage readings.

4.5 Mammography

This topic will describe how to measure kVp, dose, HVL, AGD (MGD), and time on a mammography unit using the Piranha.

4.5.1 General

To measure kVp on a mammography unit is straightforward. This is true since the Piranha automatically can detect whether the detector area is not fully uniformly irradiated, by means of the *Position Check*. The mammography kV calibrations available for the Piranha is ranging from 18 to 49 kV.

To be able to trust the kVp reading it is always very important to make the *Position Check* to verify that the whole detector area is uniformly irradiated. The *Position Check* is normally started automatically every time you change R*adiation Quality*, but please make sure to do a *Position Check* every time the Piranha is repositioned.

The kV and radiation waveform is always stored together with the RTD values and can be displayed by tapping the **Wave** button. The kVp calibration for Piranha is made without the compression paddle in place.

The purpose of dose measurement is often to determine the ESAK, *Entrance Surface Air Kerma* (or ESE, *Entrance Skin Exposure*).

It is recommended to perform dose measurements according to a mammography protocol. One is the "European Protocol on dosimetry in mammography EUR 16263 EN from the European commission". Chapter 3 in this protocol describes in detail the determination of AGD, *Average Glandular Dose* (or MGD, *Mean Glandular Dose*). The AGD is derived from measurements of the HVL and of the ESAK. Make use of tabulated conversion factors from ESAK to AGD. See Average Glandular Dose, AGD (MGD) 57.

4.5.2 Setting Up the Piranha for Mammography

To set up the Piranha:

1. Power on the Piranha using the power switch. Optionally you may connect the power supply from the power outlet to the USB port.

2. Make sure that the image receptor is positioned at a clinically relevant distance (typically 600 mm).

3. You should place the Piranha flat on the image receptor with its long axis parallel to the chest wall making sure the centre of the detector surface is placed in the centre of the light field, as shown in the pictures above (40 mm distance shown).
This placement of the Piranha makes the detector surface perpendicular to the cathode/anode axis, to avoid influence from the heel effect.

Note! For general mammography, it is important that the USB port points in the patients left direction, as shown in picture.

Tip! To be able to get comparable results, please consider the position of the Piranha. The Piranha should be placed at a clinically relevant distance from the chest wall. Recommendations for this varies, typically between 40 and 60 mm. For Europe, 60 mm is the recommended distance (Ref. ECR 16263 EU).

4. Connect the devices.
   Handheld: For Bluetooth (wireless) nothing is needed.
   PC: connect the USB cable. For Bluetooth (wireless) attach the Bluetooth adapter to the PC (if not built-in).

5. Power on the handheld computer or the PC.

Now everything is set up with the hardware. Please continue in one of the following sections, depending on what you want to measure.

4.5.3 kVp, Time, and Dose Measurements with the Internal detector

Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha for Mammography 52.

1. Select Type of Measurement and Parameter, as shown below.

2. Select the correct radiation (beam) quality.

3. Make a *Position Check*, as shown above. It is recommended to make the check at 28 kV. After the check the Piranha automatically changes back to the previously selected kV range.

4. Set kVp and mAs (or mA/time) to the desired values.

5. Make an exposure. The RTI logo flashes to indicate that the Piranha has detected the exposure.

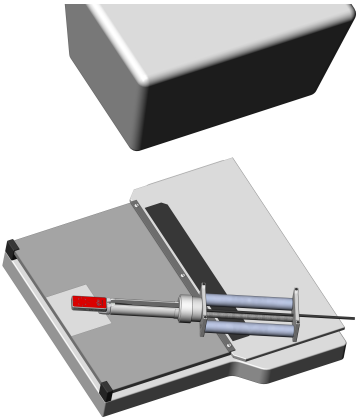
6. Read the values.

Note! There are some mammographic units that are bit peculiar when it comes to kV measurements, for instance The Hologic Selenia and IMS Giotto. In those cases, RTI have updated Application Notes, and there may be some even for other units. Please check the RTI Electronics website (www.rti.se) for the latest info. For Sectra MDM, Fischer Senoscan and other scanning beam units, please see the section Scanning Beam Mammography 58.

4.5.4 Dose Measurements with the Piranha Dose Probe

Tip! It is often more convenient to use the Piranha to measure dose for a mammography tube since no manual energy compensation has to be done, as is the case with the Piranha Dose Probe.

Measuring procedure



1. Place the Piranha Dose Probe in the field and connect the cable to the Piranha input.
2. Set up the Piranha according to the description in Setting Up the Piranha for Mammography.
3. Follow the same step as for the measurements with Piranha but select **Dose** as parameter. You will also need to select the External detector.

4. Select radiation quality from the detector list.
5. Set kVp and mAs (or mA/time) to desired values.
6. Make an exposure.
7. Read the dose value. The dose reading has to be corrected manually according to the Piranha Dose Probe DETECTOR DATA manual, unless set values for kV is used in Ocean.

Tip! You may store the correction as a *Beam Correction Factor* in a *Favourite* for a specific kV, to do the correction automatically.

Note! To get a good HVL value, using the Piranha Dose Probe, you must correct it according to the tables in the Piranha Dose Probe DETECTOR DATA manual. It is often more convenient to measure HVL with the Piranha using the built-in HVL application.

4.5.5 Quick-HVL

Quick-HVL

The Piranha is able to measure HVL for mammography in one shot. Quick-HVL is available for measurements with or without compression paddle.

4.5.6 Mammo Compensations and Corrections

Here various corrections and compensations are described, that are of special importance for mammography.

4.5.6.1 Corrections for the Compression Paddle

The Piranha is well collimated above its small detector area, and will measure the same whether the compression paddle is placed directly on top of the Piranha or high above. This is NOT true for an ion chamber.

A factor has been introduced which enables the Piranha to take the scattered radiation into consideration and produce measurement results as if it was an ion chamber which senses the scattered radiation directly.

When an ion chamber is placed directly below the compression paddle, a relatively constant scatter factor of 6 % is found. The factor is typical for ion chambers such as Radcal 6M, PTW N23344, and Standard Imaging Magna 1cc.

Typically for a Mo/Mo beam energy, a 0.10 mm Al equivalent compression paddle is used. That is equal to approximately 3 mm of plexiglass (PMMA).

For W/Al beam energy, an equivalent compression paddle of 0.18 mm Al is typically used instead.

When comparing with typical mammographic ion chambers listed above, you should multiply the Piranha dose value with a scatter factor of 1.06 to make it measure as an ion chamber directly below the compression paddle.

More info about the correction for compression paddle can be found in Application Note 1-AN-52020-2 from RTI Electronics AB. Please also see section Angular Sensitivity, Piranha 22 for details on sensitivity in different directions.

4.5.6.2 Normalization

A normalization function is available which enables all measurements to be virtually performed at the same distance, increasing productivity. According to European protocol (ECR 16263 EU, 1996), ESAK should be measured 45 mm above the breast support.

A practical consequence of usage of the normalizing function and scatter factor is that the Piranha can be kept at the same position on the breast support all the time when data is collected for AGD.
For an ion chamber it is not quite as easy because of the scatter contribution that is not allowed during HVL measurement. The ion chamber and/or the compression paddle must be moved to support good geometry.

More info about the correction and normalization function can be found in Application Note 1-AN-52020-2 from RTI Electronics AB.

4.5.6.3 Beam Correction Factor

Sometimes you may want to make comparable measurements with a known mechanical setup.

Assume that you want to emulate ion chamber measurements in a particular scattering situation. Then you can set a *Beam Correction factor* to get that reading like you used to. In this case the ion chamber measures an extra 3 % from side and back-scatter. Using this factor makes the readings to be the same. It is of course important that the mechanical setup in these cases are the same.

Note! You may use the *Beam Correction factor* to make compensations and corrections of various nature. Examples might be: energy corrections, angular corrections, field inhomogeneity corrections, etc. If you save this setting as a *Favourite*, you can have a quick way of repeatedly making a special measurement without any manual corrections.

4.5.6.4 Corrections for Angular Sensitivity

For mammography, the following correction table may be used at a SDD of 60 cm, if the Piranha is placed flat on the breast support. (This assuming that the focal point is situated at the chest wall, which normally is the case.)
You can find the product version on the label on the back side of your Piranha.

Distance from chest wall (cm)	Correction for Piranha v1.X (%)	Correction for Piranha v2.X and higher (%)
0	0	0
1	+1.9	+0.01
2	+3.8	+0.06
4	+7.6	+0.22
5	+9.5	+0.35
6	+11.5	+0.50
8	+15.3	+0.88
10	+19.1	+1.38

Note! Rule of thumb for v1.X: add 2 % per centimeter from the chest wall at 60 cm SDD, i.e. for 4 cm use +8 % correction.
As seen for product version 2.X+, no correction is necessary.

Tip! You may use the *Beam Correction Factor* together with *Favourites* in Ocean or QABrowser to automatically do a specific correction. See Beam Correction Factor 56.

See also Angular Sensitivity, Piranha 22.

4.5.7 Average Glandular Dose, AGD (MGD)

The AGD (average glandular dose) is derived from measurements of the HVL and of the ESAK, entrance surface kerma (or ESE) making use of tabulated conversion factors from ESAK (or ESE) to AGD (or MGD). The tabulated data has been derived from Monte Carlo calculations and has been verified experimentally.

To determine the AGD a standard phantom should also be used when the ESAK (or ESE) value is measured with the Piranha.

Correct measurement of the Average Glandular Dose (AGD) with the Piranha

In most situations you can perform measurements for a mammographic unit with the Piranha instead of a dedicated ion chamber. Since the Piranha compensates for energy dependence, the readings are in direct comparison with readings from a reference class ion chamber. When measuring the AGD you should always have the compression paddle in place.

Important quantities to measure

The most common measurements for a mammographic system are conducted to determine the average glandular dose (AGD). The AGD values are based on measurements of ESAK (entrance surface air kerma) and HVL. To do the measurements correctly and according to standards, the radiation detectors should be placed directly below the compression paddle. This introduces extra scattered radiation due to the compression paddle which is important to include when determining ESAK. On the other hand, the HVL measurement should be done without any scatter contribution and with good geometry.

HVL

The Piranha is well collimated above its small detector area. Due to this fact it registers a narrower angle of the X-ray field and thus much less scattered radiation compared to an ion chamber. It has built-in good geometry and is therefore ideal for HVL measurements. Hence, the HVL filter can be placed on top of the compression paddle without any extra collimation even at close distance to the Piranha. The Piranha has a built-in HVL application which should be used to get accurate HVL readings.

4.5.8 Mammographic Pre-pulses

Some mammography systems (e.g. GE DMR system) use a pre-pulse to determine what radiation quality to use for a specific patient.

The time elapsing between the pre-pulse and the real exposure is usually about one second. Therefore the default post-delay of 250 ms will not cover both the pre-pulse and the real exposure. To get an overview of the signal output, set the post-delay to at least 1 s and the waveform recording time to a corresponding time. It is important to cover both signals. In this measurement setup, the Piranha will add the dose from both pulses. This is OK if the radiation quality is not changed between the signals.

If the Mammography unit changes the radiation quality after the pre-pulse however, the kV and dose is affected and the pulses should be treated separately. To collect data from real exposure, set the delay (not the post-delay) to exclude the pre-pulse. When the data has been acquired, change the radiation quality to the one chosen by the system and the measured data is automatically corrected. For the time being, this

feature is only present in the QABrowser software. With Ocean a new exposure has to be made with the correct radiation quality using the same delay setting.

4.5.9 Scanning Beam Mammography

When measuring on scanning beam mammographic equipment, like for instance Sectra MDM or Fischer Senoscan, two factors are very important.

1. You should place the Piranha flat on the image receptor. Then position it as described in section Setting Up the Piranha for Mammography 52.
2. Always perform a position check. This makes sure than any field imbalances are corrected for.
3. If you use the compression paddle, make sure that you use the correct settings, see section Corrections for the Compression Paddle 55.

Please also see the CT section for measurement tips on scanning beams.
For Sectra L30, see special application note on the RTI Electronics website (www.rti.se).

4.6 Dental and Panoramic Dental

This topic will describe how to measure kVp, dose, and time for a Dental and Panoramic Dental X-ray units using the Piranha only.

Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha 10. To measure kVp for a dental unit is similar to measuring for a radiography units with the difference that the output level is much lower and the total filtration is normally around 2 mm Al.

The setup is straightforward and also to get the measured value. Most dental units is still single phase self-rectified and has 100 % radiation and kV ripple. In the case of one-phase dental units it is common that only the exposure time can be changed. In most cases the set tube voltage and current is fixed to about 65 kVp and 8 mA. A challenge can exist how to find a definition what measured value should be used. Furthermore the radiation output and the kV waveform are not stable for the first 200 ms or so, because that the tube filament current in most cases is not regulated.

The definition of both what is the true kVp and exposure time cannot be as easily determined without study the waveform and select appropriate measurement parameters as delay and window. Introducing small CCD detectors instead of film also demands carefully calibration of single phase dental systems. The tube voltage waveform is collected from 200 ms after start trig and the kVp is calculated based on the measuring window equal the remaining part of the exposure time.
The dose value is collected for the whole exposure time. If you need to change the sensitivity, delay, or/and measuring window, tapto show the settings and make your choices.

In the case of dental panoramic system the situation is somewhat different. Here the kV and radiation waveform often is very well regulated.

The challenges instead arise for the mechanical setup needed to position the detector in right position. The small and narrow field is only a few millimetres. The Piranha detector has very narrow detector area and is very thin and a special holder (optional) can be used to position the Piranha without any problem. Panoramic units that use digital detectors have much smaller detector area and magnets cannot and should not be used

close to the detector area.

Special fixation rods for the head should be placed so that they are not in the beam during the scan or can hit the detector. In most cases the control panel have a special scan mode without X-ray so the mechanical set up can be tested.

Another important issue to be aware of is that a dental panoramic system normally compensates the for the thicker penetrating neck region in the patient when it makes its scan. This means that some units actually increase its tube voltage a short moment during the scan, other use different mA or scan speeds when the scanning beam passes the neck region. Newer digital system can actually measure patients X-ray beam attenuation dynamically and change the output level automatically during the scan.

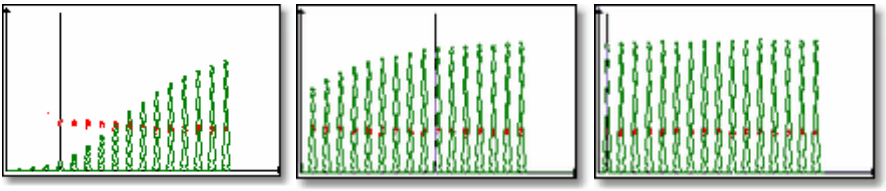
The Piranha has addressed these challenges. Since the panoramic scan has an exposure time of about 10 to 20 seconds, the Piranha is set up to continuously update the display during the scan. It is preferable to select a single parameter display and angle the Palm holder, making it easy to read the values during the scan, from a distance.

You can always trust the kV reading of a dental measurement. This is true since Piranha can automatically detect whether the detector area is not fully uniformly radiated or not by means of the *Position Check*, and also compensates for the beam filtration during the scan.

You can either select the tube voltage as single parameter or together with dose, dose rate, and exposure time. As complementary information an estimation of the total filtration in the beam and type of waveform are made. This features use the kVp filter R1[4] that also is the default kV range 55 - 105 kV when the instrument is turned on. The displayed dose value has very little energy dependence since it is automatically compensated for each exposure since the kV, estimated filtration and the waveform are measured.

4.6.1 Waveforms

The example below explains why a change of delay change the value of measured kVp and the kV and radiation waveform on a one phase dental unit.



Delay = 0 ms **Delay = 200 ms** **Delay = 500 ms**

From the study of the above three screens several conclusions can be made:

1. A stable output level is not reached until after approximately 200 to 300 ms (20 to 30 pulses for a 50 Hz main based dental unit).

2. The exposure time is depending on the definition of the trig level.

3. The kVp value in the RTD is related to selected delay and window and is several kV higher in the beginning of the exposure at the same time as the radiation level is relative low here. Therefore a delay of 200 ms is default for the Piranha.

Note! If the signal to the detector is too low to give a correct kV value, this part of the waveform will be blank. This is the reason why only the upper parts of the kV waveform is displayed. To see more of the waveform, change the kV range.

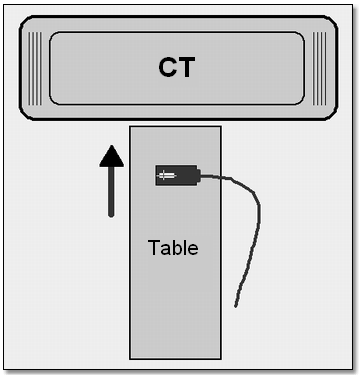
4.7 CT

4.7.1 CT kVp

To measure kVp on a CT is many times difficult since with most meters it is required to stop the tube in the top position at the same time as the table is not moving. This can normally not be obtained using an available standard clinical program. Instead a service mode must be used. Another problem is to "find" the beam, especially when using a small slice width. All these problems are minimized when using the Piranha since it can "move with the table" through the beam while the tube is in the top position. This is can easily be obtained by measuring while a topogram (scout/pilot image) is taken. A topogram is obtained with a moving table and a stationary tube, normally in the top position. The topogram is normally used to provide information for the actual CT scan. It is recommended to use a slice width of 3 mm or wider. That is, if selectable use as large slice width as possible.
You may also want to use the *Timed* mode to allow measurements on moving CT machines, see section Update Modes 40.

To measure CT kVp:

1. Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha 10.



2. Place the detector on the patient bed in a region that is irradiated during the topogram process. Place the Piranha in the direction indicated by the figure below. That is, the Piranha detector surface rectangle should be placed perpendicular to the scanning direction.

   You may use the lasers to align the Piranha correctly.

3. Select **Tube voltage**.
   The following calibrations are available:
   C1 = W/3.0 mm Al
   C2 = W/3.0 mm Al + 0.25 mm Cu (optional)
   C3 = W/3.0 mm Al + 1.2 mm Ti (optional)
   C4 = GECT
   C5 = Toshiba Aquillion

4. Make a check of the position of the Piranha by using the *Position Check* function.

5. Set up the CT to make a topogram.

6. Start the topogram program. If the procedure includes more than one topogram you may abort after the one taken with the tube in the top position.

   If the Piranha is positioned in a correct way, the position is accepted and the real-time display is shown again. If not check the position of the Piranha and/or increase the slice width if possible.

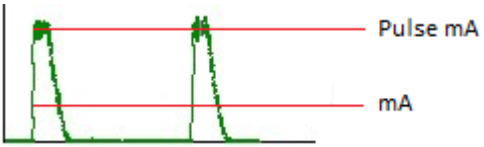
7. You are now ready to measure. Repeat the topogram program to measure kVp.

   The exposure time you measure is not related to the actual "radiation time". It is the time it takes for the detector to "pass through" the CT X-ray field when the table moves when it is acquiring the topogram.

4.8 Tube Current Probes

The mAs probes are used to measure mAs (current time product) and mA (tube current). Tube current is normally measured only for fluoroscopy or when long exposure times are possible to allow read-out during the exposure. When tube current is presented for exposures it has been calculated from the measured mAs and from measured exposure time.

For pulsed fluoroscopy it is possible to measure pulse mA in addtion to the mA value. The difference between the pulse mA and the traditional mA is explained in the picture below.



(Note that for DC waveform, pulse mA and mA gives the same value.)

You can measure mAs as a single parameter or multi-parameter together with the Piranha. When using only the mAs-probe the measurement always starts when the mAs-probe detects a signal. When using multi-parameter you can choose to trig individually or to trig with the Piranha:

Individually: The mAs-probe starts to measure as soon as the tube current is detected. The Piranha starts to measure as soon as it detects the radiation. Normally will the mAs-probe start to measure first since tube current first charges the HV cables before it "reaches" the tube and radiation is generated.

Piranha: Both the mAs-probe and the Piranha starts to measure at the same time; when the Piranha detects radiation. This is the easiest way to measure since there is almost no risk for false triggering.

It is important to be aware of that measured mAs-values may differ depending on which trig method is used. Especially when measuring low mAs values the difference may be significant when comparing the two methods or comparing to "traditional" mAs meters. The value you get when triggering on the tube current (Individual trig) corresponds to the total mAs supplied from the generator. A part of that has been used to charge the cables and the rest has reached the tube and contributed to the exposure and the image. When you use Piranha trig you measure only the mAs that actually contributes to the exposure and the generation of the image.

The discussion above is generally true for the invasive MAS-1 probe since it is connected in the transformer and measures "all" current. The non-invasive probes, MAS-2 and MAS-3, can be placed anywhere on the HV cable. If they are placed close to the tube they will measure only the current that floats through the tube and contributes to the radiation and the choice of trig source will have limited influence on the measured values.

When measuring on fluoroscopy the trig source has no influence and it is recommended to trig on the Piranha.

4.8.1 MAS-1, Invasive mAs Probe

This section describes how to measure the tube current and charge as a single parameter. This means that the measurement starts when the mAs-probe detects the tube current. The measurement is performed in the same way if you use a multi-parameter display. In that case the default trig is the Piranha and what is said below about false triggering can be ignored.

The MAS-1 probe provides an invasive way to measure mA and mAs on X-ray generators. The MAS-1 probe should be connected to the X-ray generator mAs socket. The figure to the left shows the Piranha MAS-1 Probe. Read the MAS-1User's Manual for a detailed description on how to connect it.

To measure tube charge (mAs) with the Piranha MAS-1 Probe

1. Connect the MAS-1 probe to the X-ray generator as described in the MAS-1 User's Manual.

2. Connect the MAS-1 probe to the external probe input.

3. Place the Piaranha internal detector in the X-ray field as for a normal exposure and continue measure as for a standard measurement.

If you get a message about **Negative Signal**, the current is floating in the wrong direction in the mAs probe. Switch the two connectors that are connected in the mAs measuring socket, do a **Reset** and make a new exposure.

Since the MAS-1 probe is connected in the X-ray generator false triggering may occur due to electrical noise when the pre-heat is started and the anode starts to rotate. If you get incorrect or inconsistent results try the following:

- First start anode rotation without firing the exposure.
- While the anode is rotating do a **Reset** or press the corresponding button. Make the exposure when the reset procedure is finished.

The MAS-1 probe can also be used for measurement of tube current during fluoroscopy.

To measure fluoroscopy tube current with the Piranha MAS-1 Probe

Do as for tube charge (mAs) as described above, but please note that for low mA values the mAs and the exposure time may not be measured.

4.8.2 MAS-2, Non-invasive mAs Probe

This section describes how to measure mAs, using the Piranha in the x-ray beam to trigger the measurement. This means that the measurement starts when the Piranha detects the radiation.

The MAS-2 probe uses a current clamp probe to measure mAs and mA non-invasively.

The MAS-2 probe is mostly used for mAs measurements since it is not sensitive enough to measure tube current on fluoroscopy. The lowest tube current that can be measured with MAS-2 is 10 mA. The figure to the left shows the MAS-2 probe without the cable.
The parameter mAs is available for most type of measurements but mAs is normally measured only for X-ray exposures.

To measure tube charge (mAs) with the Piranha MAS-2 Probe

1. Connect the MAS-2 probe to the X-ray generator. Then power on the MAS-2 by turning the range switch to the 4 A range and make a Reset of the MAS-2 probe by pressing the yellow knob on the probe.

2. Connect the MAS-2 adapter cable to the Piranha.

3. Place the Piranha internal detector in the X-ray field as for a normal exposure and continue measure as for a standard measurement.

4. Make sure to use the Piranha internal detector as trig source. This will make the system trigger on the radiation, and thereby avoid self-triggering by ground loops in the high tension cables.

5. Do a **Reset** before the first exposure.

6. Make an exposure.

If you get a message **Negative Signal**, the mAs probe is probably connected in the wrong direction. Change the direction of the mAs probe, press the Reset button on the mAs probe, do a **Reset**, and make a new exposure.

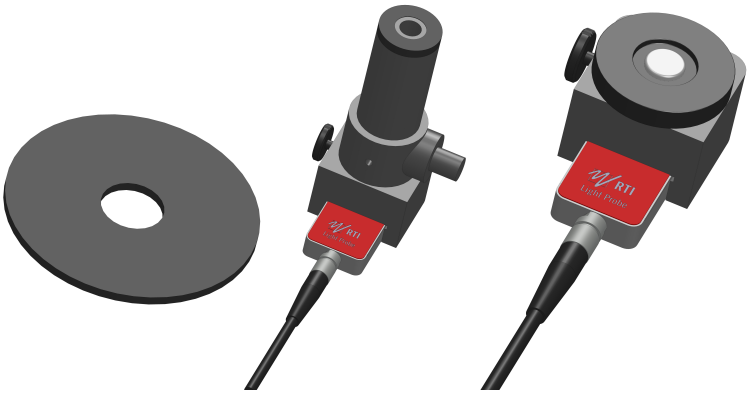
If using Individual trig
Since the MAS-2 probe is based on measurement of magnetic flux, false triggering may occur due to electrical noise when the pre-heat is started and the anode starts to rotate. If you get incorrect or inconsistent results try the following:

- First start anode rotation without firing the exposure.

- While the anode is rotating tap **Reset** or press corresponding button. Make the exposure when the reset procedure is finished.

4.9 Light Measurement

The Piranha Light Probe is a highly sensitive light detector. It has two different adapters to measure the quantities luminance and illuminance. The most common applications for the Piranha Light Probe are luminance (cd/m²) measurements on CRTs (monitors) and viewing boxes, and illuminance (lx) measurements of ambient light in a room or in front of a CRT. Read the Piranha Light Probe User's Manual for a detailed description of practical use and explanation of the theory behind the units and quantities of light.



The monitor adapter is shown to the left and the lux adapter to the right.

4.9.1 Luminance - Monitor/Viewbox (cd/m²)

Read the Piranha Light Probe User's Manual to get information about how to do different type of measurements and how to use the different adapters.

To measure luminance (cd/m²):

1. Attach the monitor adapter to the Piranha Light Probe as described in the Piranha Light Probe User's Manual.

2. Connect the Piranha Light Probe to the Piranha.

3. Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha 10.

4. Make a Reset. Place the Piranha Light Probe onto the surface where you want to measure the luminance.

5. Press and hold the shutter. Read the value. You can now move the Piranha Light Probe to other points and continue measure the light.

4.9.2 Illuminance - Ambient Light (lx)

Read the Piranha Light Probe User's Manual to get information about how to do different type of measurements and how to use the different adapters.

To measure illuminance (lx):

1. Attach the lux adapter to the Piranha Light Probe as described in the Piranha Light Probe User's Manual.

2. Connect the Piranha Light Probe to the Piranha.

3. Set up the Piranha and the handheld computer according to the description in Setting Up the Piranha 10.

4. Cover the white light-sensitive area of the Piranha Light Probe to shield off all light (you may use the rubber part that comes with the Piranha Light Probe-M if available). It is very important that you shield off all light. Then make a **Reset**. After that you can remove the shield and place the light detector where you want to measure the ambient light.

5. Read the value. You can now move the Piranha Light Probe-L to other points and measure the ambient light.

Chapter 5

Problems and Solutions

5 Problems and Solutions

5.1 Troubleshooting

Before contacting your distributor or RTI Electronics, please check the following tips.

A. Check the RTI web page for updates http://www.rti.se.

B. Run through the checklist below.

The Piranha does not work
Check:
1. Check that the motor moves properly or can beep. (QABrowser: **Setup | System Test**).

The Piranha filter seem to have stuck
1. Start the QABrowser and run the filter test. (QABrowser: **Setup | System Test**)
2. Hold the Piranha in you right hand by the cable edge.
3. When the motor is trying to move, tap the Piranha's left long edge in the palm of your left hand until it comes free.

The electrometer does not give a reading
Check:
1. That the correct input connector is used and connected.
2. That probe cables look healthy.

The electrometer gives numerous trig indications
If you get the trig indicator ("play" symbol) when there is no signal:
1. Press reset.
2. If it comes over and over you may need to increase the trig level, by raising the threshold, see topic Settings.

The electrometer or Piranha gives too low dose rate
If you get to low dose rate readings or too short irradiation times for short exposures:
1. Check that you are measuring with a good geometry, where the incoming radiation is perpendicular to the detector surface. See Specifications, Piranha 12 for details.

Installation or upgrade of RTI Updater failed
Make sure you are not having a restricted user account (on Windows XP, 2000, or newer). You will need to have access to an administrative account to install the software, see section Windows Restricted User Accounts for details.

My Piranha cycles its status indicator quickly between colours and does not measure
Your system is in Bootloader mode. Please run RTI Updater to correct this.

My Piranha beeps twice quickly when starting
The Piranha normally beeps once when starting. If it beeps twice quickly when powering on, run RTI Updater to correct this.

Bluetooth unable to reconnect using Retry
Tap **Exit** and restart the Piranha and then re-start the QABrowser again.

Bluetooth only shows "Unknown device" when trying to connect
Depending on Palm model it may take a little while for the serial number to appear, the Piranha will appear as "Unknown device". Normally it will show the serial number if you wait a while.
Can I set the time before the Handheld powers off automatically?
Yes, there is a preference setting for this (**pull-down menu | Setup | Preferences**), see Preferences Setup.

How do I reset the Handheld computer?
There is a small reset hole on the back of the Handheld computer, use the stylus (pointer) to reset.

C. Contact your local representative or see Notice for contact information to RTI Electronics AB. The more information you supply will help us to get a quick solution to your problem. Examples of useful information is screen dump pictures, exact error message texts, log files, etc. You may also use the auto-report function described in the section How To Report a Problem 71.

5.2 Bluetooth

Bluetooth is a wireless way of communication between your PC/handheld and your meter. The Piranha has built-in support for this, but with the Barracuda you need the *Barracuda Serial Bluetooth Module* accessory. A Palm OS handheld also has built-in support for Bluetooth but a PC may or may not have built-in support for Bluetooth. If the PC does not have built-in Bluetooth support you will need a Bluetooth adapter (that you connect to the USB port) for instance the D-Link DBT-120 or DBT-122.

The range of Bluetooth is about 10 meters (32 feet) in free air for a class 2 Bluetooth adapter (like the D-Link DBT-122), for a class 1 Bluetooth adapter (like the Targus ACB20EU) the theoretical range is up to 100 metres. This can be significantly shorter if there are walls and other objects obstructing the signal.

Bluetooth and a Palm OS handheld works out of right out of the box, while using Bluetooth and PC usually requires some work. If it is possible for you to use a USB cable with your PC and meter then this is recommended.

5.2.1 Bluetooth Passkey

There are two different ways to use Bluetooth with you meter, without a passkey and with a passkey (also called PIN code, authentication, and Bluetooth security code). All meters and accessories that are delivered from RTI Electronics from the first quarter of 2010 are configured to use a passkey (0000).

Drawbacks of using a Passkey

If you enable a passkey you might experience some drawbacks.

- If you use your meter (with Bluetooth communication) with more than one PC or with a PC and a Palm OS handheld you might need (depending on your hardware) to add the meter (also called to pair a device, or to add as a trusted device) with the PC/ handheld every time you have used another PC or handheld with the meter.

- With a Palm OS handheld you cannot just simply start the QABrowser with Bluetooth. You need to first add the meter as a trusted device. And if you have used the meter with another handheld or PC (using Bluetooth) you will need to add the meter as a trusted device again.

New hardware which supports multiple devices
Piranha with product version 3.0 (which started shipping around spring 2009) and higher, and product version 2.5.4 supports multiple Bluetooth devices, which means that you can use it with both a PC and handheld without additional steps.

Advantages of using a Passkey

- Works with Windows Vista and Windows 7-8.
- Increased security

The main reason to change so that you use a passkey is if you are going to use Bluetooth communication and Windows 7-8, Vista, or Windows XP and a Bluetooth adapter where you cannot disable authentication. But we recommend that you use a USB cable if you can.

If you want to use a passkey and have previously not been using one, you need to reconfigure your Piranha/Barracuda Serial Bluetooth module. Detailed instructions are available later on in this manual.

5.2.2 Enable Bluetooth Passkey

Before you enable the use of a Bluetooth passkey please read the section about Bluetooth passkeys and the drawbacks of using a passkey.

You enable and disable passkeys by using the *RTI Updater* application (requires version 2008.6A or later) which is available on your RTI Software & Documentation CD and the RTI website (www.rti.se).

1. Connect your meter using the USB cable. If you are using a Barracuda then also connect the Barracuda Serial Bluetooth Module.
2. Launch RTI Updater from the RTI Electronics folder in the Windows start menu.
3. Select the USB connection. You cannot use a Bluetooth connection when you want to change the Bluetooth configuration. A Bluetooth connection is shown as **COMxx**.
4. Wait for RTI Updater to finish with the startup procedure. After a while when it is ready the **Start** button will be enabled.
5. Select **Settings | Advanced** from the menu.
6. Now select the **Tools** menu.
7. If you want to enable the use of a passkey select **Enable Bluetooth Passkey**. If you experience problems with this, then you probably need to update you meter firmware before you can enable the Bluetooth passkey. Please run the available updates (by pressing **Start**) and then restart the application again to enable the Bluetooth passkey.
8. Follow the onscreen instructions.

If you want to disable the Bluetooth passkey do the same thing but select **Disable Bluetooth Passkey** instead. If you are asked for a PIN code during the startup do **not** enter a PIN code, just cancel instead. Because if you do, you will have activated your Bluetooth and RTI Updater cannot reconfigure the Bluetooth module when it is active.

5.3 How To Report a Problem

There is a way of automatically sending technical support information to RTI Electronics AB when you are experiencing problems with the QABrowser.

This is how you use that functionality:

1. HotSync the Palm handheld that you are experiencing the problem with.
2. On your PC, go to **Start Menu | All Programs | RTI Electronics | QABrowser Updater** and click **Send Support Information**.
3. A dialogue window will be shown. Please enter a description of the problem. Tip! The more information you give, we will have better chances of reproducing the problem and finding a solution to it.
4. Click **Send** to send the auto-generated email.

Chapter 6

Glossary

6 Glossary

Absorbed dose (D)
The energy imparted per unit mass by ionizing radiation to matter at a specified point. The SI unit of absorbed dose is joule per kilogram (J/kg). The special name for this unit is gray (Gy). The previously used special unit of absorbed dose was the rad. 1 rad = 0.01 Gy. 1 Gy = 100 rad. (See Report No. 82, NCRP, 1985b.)
SI unit: Gy = J/kg

Absorbed dose rate (D')
absorbed dose per unit time. Absorbed dose rate is determined as the quotient of dD by dt, where dD is the increment of absorbed dose in the time interval dt: D'=dD/dt. A unit of absorbed dose rate is any quotient of the gray or its multiples or submultiples by a suitable unit of time (Gy/s, mGy/h, etc.).
SI unit: Gy/s = J/kg·s

Absorption, energy
Phenomenon in which incident radiation transfers to the matter which it traverses some or all of its energy.

Activity
The number of nuclear transitions occurring in a given quantity of radioactive material per unit time. The SI unit of activity is s^{-1}. The special name for the unit of activity is becquerel (Bq). The previously used special unit of activity was the curie (Ci). 1 Bq = 2.7 x 10^{10} Ci. 1 Ci = 3.7 x 10^{10} Bq. (See Report No. 82, NCRP, 1985b.)
SI unit: Bq = s^{-1}

Additional filtration
ADDED FILTERS and other removable materials in the RADIATION BEAM which are between the RADIATION SOURCE and the PATIENT or a specified plane.
See also filter.

Air kerma
See kerma.

Aluminium equivalent or Aluminium Attenuation Equivalent (AAE)
The thickness of aluminum affording the same attenuation, under specified conditions, as the material in question.

Anode
In a X-ray tube, electrode to which electrons forming a beam are accelerated and which usually contains the target.

Aperture
(e.g., for computed tomography) - the opening in the collimation that allows radiation to reach the detector.

Area exposure product
Product of the area of a cross-section of a radiation beam and the averaged exposure over that cross-section.
SI unit: Gy·m^2

Attenuation
The reduction of radiation intensity upon passage of radiation through matter.

Automatic exposure control (AEC)
In an X-ray generator, mode of operation in which one or more loading factors are controlled automatically in order to obtain at a preselected location a desired quantity of radiation.

Automatic exposure rate control
In an X-ray generator, mode of operation in which the rate of emitted radiation is controlled automatically by control of one or more loading factors in order to obtain at a preselected location and in a preselected loading time a desired quantity of radiation.

Beam limiting device
Device to limit the radiation field.

Becquerel (Bq)
The special name for the SI unit of activity. One becquerel is one reciprocal second or 1 s^{-1}. 3.7×10^{10} Bq = 1 Ci.

Bootloader
General: a program that does the job of loading the OS kernel of a computer.
Piranha bootloader: Miniature program stored in cabinet and modules which normally just starts the Firmware. It is used more when the Firmware is updated. See Firmware.

Centigray
0.01 gray. 1 cGy equals one rad.

Cinefluorography
The production of motion picture photographic records of the image formed on the output phosphor of an image intensifier by the action of X-rays transmitted through the patient (often called cineradiography).

Cineradiography
Indirect radiography of moving objects usually in rapid series on cine film.

Collimator
See beam limiting device.

Compensating filter
Filter used in order to modify the distribution of absorbed dose rate over the radiation field.

Computed tomography (CT)
An imaging procedure that uses multiple X-ray transmission measurements and a computer program to generate tomographic images of the patient.

Continuous mode
For an X-ray generator, mode of loading an X-ray tube continuously as in radiotherapy or in radioscopy.

Conversion factor (of an image intensifier)
The quotient of the luminance of the output phosphor of the image intensifier divided by the kerma rate at the input phosphor.
SI unit: $cd/m^2 / Gy/s = cd \cdot s/Gy \cdot m^2$

CT
See Computed Tomography

CT number

One of a set of numbers on a linear scale which are related to the linear attenuation coefficients calculated by a computed tomographic device. One of the specific set of CT numbers on a scale from -1000 for air to +1000 for bone, with water equal to zero, which is called a Hounsfield unit.

Curie (Ci)

The previously used special unit of activity equal to 3.7 × 1010 per second. 1 Ci = 3.7×10^{10} Bq.

Dead man switch

A switch so constructed that a circuit-closing contact can be maintained only by continuous pressure on the switch.

Dental panoramic radiographic

Direct radiography of a part of or the complete dentition by the use of an intra-oral X-ray tube. See also Orthopantomography.

Diagnostic source assembly

A diagnostic source housing (X-ray tube housing) assembly with a beam limiting device attached. This assembly shall be so constructed that the leakage radiation air kerma measured at a distance of one meter from the source does not exceed 1 mGy (0.1 rad) in one hour when the source is operated at its leakage technique factors. (See definition).

Digital radiography

A diagnostic procedure using an appropriate radiation source and an imaging system which collects processes, stores, recalls, and presents image information in a digital rather than analogue fashion.

Digital subtraction

An image processing procedure used to improve image contrast by subtracting one digitized image from another.

Dose equivalent (H)

A quantity, defined for radiation protection purposes, which is the product of the absorbed dose to the tissue and a quality factor "Q" determined by the properties of the radiation that produced the absorbed dose. For X-rays, gamma rays, and electrons, Q = 1 and dose equivalent values are numerically equal to absorbed dose values when consistent units are used for both quantities. The SI unit for dose equivalent is joule per kilogram. The special name for the SI unit of dose equivalent is sievert (Sv). The previous special unit of dose equivalent was the rem. One sievert equals 100 rem.
SI unit: Sv = J/kg

Dose rate meter

Radiation meter intended to measure absorbed dose per unit time.

Dosemeter

Radiation meter intended to measure absorbed dose.

Effective dose equivalent (HE)

Quantity used to express the weighted DOSE EQUIVALENT to the whole body when it is irradiated non uniformly or partially.

Exposure (X)
A measure of the quantity of X-ray or gamma radiation based upon its ability to ionize air through which it passes. The SI unit of exposure is coulomb per kilogram. The previously used special unit of exposure was röntgen (R). 1 R = 2.58 × 10^{-4} C·kg^{-1} (exactly). The physical quantity exposure is now replaced by
the quantity kerma in air. An exposure of 114.1 R is equal to an Air Kerma of 1 Gy. That means that the value in R should be multiplied by 8.76 to get the Air Kerma in mGy.
SI unit: C/kg

Exposure rate (X')
Exposure per unit time. Exposure rate is determined as the quotient of dX by dt, where dX is the increment of exposure in the time interval dt: X' = dX/dt. A unit of exposure rate is any quotient of the unit of exposure or its multiples or submultiples by a suitable unit of time ((C/kg)/s, (mC/kg)/h, etc.).
SI unit: C/kg·s

Filter
In radiological equipment, material or device provided to effect filtration of the radiation beam.
SI unit: mm

Filter: Inherent filter
The filter permanently in the useful beam; it includes the window of the X-ray tube and any permanent enclosure for the tube or source. Replaced by term Permanent filter

Filter: Added filter
Filter in addition to the inherent filtration.

Filter: Permanent filter
The filter permanently in the useful beam; it includes the window of the X-ray tube and any permanent enclosure for the tube or source.

Filter: Total filter
The sum of the permanent and added filters.

Firmware
General: The operating system and software installed on a small device. Sometimes called embedded software.
Piranha firmware: Program stored in cabinet and modules which handles all control of measurement electronics. Can be updated, then a special part of the firmware called bootloader, is used. See Bootloader.

Fluorography
The production of a photographic record of the image formed on the output phosphor of an image intensifier by the action of X-rays transmitted through the patient.

Fluoroscopy
Technique of radioscopy by means of a fluorescent screen.

Focal spot, effective
The apparent size of the radiation source region in a source assembly when viewed from the central axis of the useful radiation beam.
SI unit: dimensionless (corresponding to a dimension in mm)

Framing
In cinefluorography, the registration of the circular image of the output phosphor on the rectangular film element or frame.

Gantry
The moveable patient table used for CT.

Geometric unsharpness
Unsharpness of the recorded image due to the combined optical effect of finite size of the radiation source and geometric separation of the anatomic area of interest from the image receptor and the collimator.

Gray (Gy)
The special name for the SI unit of absorbed dose, kerma, and specific energy imparted equal to one joule per kilogram. One gray equals one joule per kilogram. The previous unit of absorbed dose, rad, has been replaced by the gray. One gray equals 100 rad.

Half-value layer (HVL)
Thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the kerma rate by one-half.
SI unit: mm

Heel effect
Non-uniform intensity observed because a small fraction of the X-ray beam emitted in a direction nearly parallel to the angled target surface must pass through more target material before escaping from the target than does the major portion of the beam which is emitted more perpendicularly. (Note: In addition to the non-uniform intensity the angled target also produces non-uniform image resolution due to variations in apparent focal spot size as viewed from various positions on the film).

Hounsfield units
See CT number.

Image intensifier
An X-ray image receptor which increases the brightness of a fluoroscopic image by electronic amplification and image minification.

Image receptor
A system for deriving a diagnostically usable image from the X-rays transmitted by the patient. Examples: screen film system; stimulable phosphor; solid state detector.

Inherent filtration
Filter between the radiation source and the output window of the X-ray equipment. See filter.

Initial X-ray tube voltage
In a capacitor discharge X-ray generator, X-ray tube voltage at the beginning of the loading of the X-ray tube.

Installation
A radiation source with associated equipment, and the space in which it is located.

Interlock
A device used to assure proper and safe use of a radiation installation by monitoring (usually by electrical devices) the status, presence or position of various associated

devices such as source position, collimator opening, beam direction, door closure, filter presence, and preventing the production or emission of radiation if the potential for an unsafe condition is detected.

Ionization

Formation of ions by the division of molecules or by the addition or removal of electrons from atoms or molecules.
SI unit: C, Coloumb

Ionization chamber

Ionization detector consisting of a chamber filled with a suitable gas, in which an electric field, insufficient to induce gas multiplication, is provide for the collection at the electrodes of charges associated with ions and the electrons produced in the sensitive volume of the detector by ionizing radiation.

Ionization constant

For air the ionization constant W/e = 33,97 J/C. The ionization constant is used to get the correspondence between exposure and air kerma. See Roentgen and Gray for more information.

Ionization detector

Radiation detector based on the use of ionization in the sensitive volume of the detector.

Irradiation time

Irradiation time is usually the time a rate of a RADIATION QUANTITY exceeds a specified level. Irradiation time is sometimes called Exposure time.
SI unit: s, second

Kerma (K)

The sum of the initial kinetic energies of all the charged ionizing particles liberated by uncharged ionizing particles per unit mass of a specified material. Kerma is measured in the same unit as absorbed dose. The SI unit of kerma is joule per kilogram and its special name is gray (Gy). Kerma can be quoted for any specified material at a point in free space or in an absorbing medium. Typically the kerma is specified in air.
SI unit: Gy = J/kg

Kerma rate (K')

Kerma per unit time. Kerma rate is determined as the quotient of dK by dt, where dk is the increment of kerma in the time interval dt: K'=dK/dt. A unit of kerma rate is any quotient of the Gray or its multiples or submultiples by a suitable unit of time (Gy/s, mGy/h, etc.).
SI unit: Gy/s = J/kg·s

Kilovolt (kV)

A unit of electrical potential difference equal to 1000 volts.

kVp

See Peak tube voltage

Lead equivalent

The thickness of lead affording the same attenuation, under specified conditions, as the material in question.

Leakage radiation
All radiation coming from within the source assembly except for the useful beam. (Note: Leakage radiation includes the portion of the radiation coming directly from the source and not absorbed by the source assembly, as well as the scattered radiation produced within the source assembly).

Magnification imaging
An imaging procedure carried out with magnification usually produced by purposeful introduction of distance between the subject and the image receptor.

Measured value
Estimate of the true value of a quantity, derived from the indicated value of a meter after applying all relevant correction factors.

Medical diagnostic radiology
Medical diagnosis using ionizing radiation.

Modulation transfer function (MTF)
A mathematical entity that expresses the relative response of an imaging system or system component to sinusoidal inputs as a function of varying spatial frequency, which is often expressed in linepairs per millimetre (lp/mm), the correct unit is however m^{-1} (or often mm^{-1}). The reference value most commonly used is that for zero frequency. The MTF can be thought of as a measure of spatial resolution of the detector system.
SI unit: m^{-1}

Monitor, personnel
See personnel monitor.

Occupancy factor (T)
The factor by which the workload should be multiplied to correct for the degree of occupancy (by any one person) of the area in question while the source is in the "ON" condition and emitting radiation. This multiplication is carried out for radiation protection purposes to determine compliance with the dose equivalent limits.

Operator
Any individual who personally utilizes or manipulates a source of radiation.

Orthopantomography
Orthopantomography (also called OPG or Panorama) is a radiographic procedure that produces a single image of facial structures including the upper and lower dentition jaws and their supporting structures and bones. Mostly used in dental applications. An OPG ("orthopantomogram") gives a panoramic view of the mouth, giving information on the teeth and the bones of the upper and lower jaw.

Particle fluence
Number of particles incident on a sphere, divided by the cross-sectional area of the sphere.
SI unit: m^{-2}

Personnel monitor
Also known as personal monitor. An appropriately sensitive device used to estimate the absorbed dose received by an individual.

Peak tube voltage Ûo (kVp)
The peak value of the tube voltage (corresponding to the highest available radiation

energy).

Phantom

In medical radiology, object behaving in essentially the same manner as tissue, with respect to absorption or scattering of the ionizing radiation in question. Phantom are used, for example, for simulating practical conditions of measurement:
- for purposes of radiation protection,
- for evaluating the performances to the diagnostic systems with respect to the radiation or to the object,
- for dosimetry.

Pixel

A two-dimensional picture element in the presented image.

Practical Peak Voltage (PPV)

The PPV is the constant potential producing the same image contrast as the waveform under test. PPV is defined in the IEC 61676 standard as: "The PRACTICAL PEAK VOLTAGE is based on the concept that the radiation generated by a high voltage of any waveform produces the same AIR KERMA contrast behind a specified PHANTOM as a radiation generated by an equivalent constant potential. The constant potential producing the same contrast as the waveform under test is defined as PRACTICAL PEAK VOLTAGE".

Primary protective barrier

See protective barrier

Protective apron

An apron made of radiation absorbing materials, used to reduce radiation exposure.

Protective barrier

A barrier of radiation absorbing material(s) used to reduce radiation exposure.

Protective glove

A glove made of radiation absorbing materials used to reduce radiation exposure.

Rad

The previously used special unit of absorbed dose. It is equal to 100 ergs per gram. 1 rad = 0.01 Gy (10^{-2} gray).

Radiation (ionizing)

Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, by interaction with matter. Examples are X-ray photons, charged atomic particles and other ions, and neutrons.

Ripple factor

The variation in the high-voltage expressed as the percentage of the maximum high-voltage across the X-ray tube during X-ray production: Ripple factor (%) = 100 x (Vmax - Vmin)/Vmax

Radiation protection survey

An evaluation of the radiation safety in and around an installation, that includes radiation measurements, inspections, evaluations, and recommendations.

Radiation receptor

Any device that absorbs a portion of the incident radiation energy and converts this portion into another form of energy which can be more easily used to produce desired

results (e.g., production of an image). See image receptor.

Radiation source
The region and/or material from which the radiation emanates.

Radiogram
A film or other record produced by the action of X-rays on a sensitized surface.

Radiography
The production of images on film/image detector by the action of X-rays transmitted through the patient.

Receptor
See radiation receptor.

Receptor assembly
A radiation receptor in the specialized container necessary for the proper operation of the receptor.

Rem
The previously used special unit of dose equivalent. One rem equals 10^{-2} sievert (Sv).

Resolution
In the context of an image system, the output of which is finally viewed by the eye, it refers to the smallest size or highest spatial frequency of an object of given contrast that is just perceptible. The intrinsic resolution, or resolving power, of an imaging system is measured in mm^{-1} or line pairs per millimeter (lp/mm), ordinarily using a resolving power target. The resolution actually achieved when imaging lower contrast objects is normally much less, and depends upon many variables such as subject contrast levels and noise of the overall imaging system.

Roentgen (R) (or Röntgen)
The previously used special unit of exposure. 1 R = 2.58 × 10^{-4} C/kg. – Originally (Stockholm 1928) defined as "international R." (Symbol: r) and later (Chicago 1937) modified to: Roentgen- or γ-ray, that gives a charge of 1 esE from secondary emission in 0,001293 g of air.
This means that an exposure of one Roentgen will produce 2,58 × 10^{-4} coulomb of ions of either sign per kilogram in air. Here the previously used physical quantity exposure has been replaced by kerma in air. See kerma. One R does not equal 1 cGy as the units C/kg and J/kg are different. To do this conversion the ionization constant for air must be used, which is 33,97 J/C. This is how its calculated: 1 Gy = 1 J/kg Û 1 J/kg/ (2,58 × 10^{-4} C/kgR × 33,97 J/C) = 114,1 R. An exposure of 114,1 R thus equals an Air Kerma of 1 Gy. That also means that the value in R should be multiplied by 8,76 to get the Air Kerma in mGy. (See also Exposure.)

Scattered radiation
Radiation that, during passage through matter is changed in direction. (It is usually accompanied by a decrease in energy.)

Serial radiography
A radiographic procedure in which a sequence of radiographs is made rapidly by using an automatic cassette changer, image intensifier/TV chain, etc.

Shutter
In beam therapy equipment, a device, attached to the X-ray or gamma-ray source

housing to control the "ON" or "OFF" condition of the useful beam.

Sievert (Sv)
The special name for the SI unit of dose equivalent. One sievert equals one joule per kilogram. The previously used unit was the rem. One sievert is equal to 100 rem.

Signal-to-noise ratio
For video cameras, the ratio of input signal to background interference. The greater the ratio, the clearer the image.

Simulator
Diagnostic energy X-ray equipment used to simulate a therapy treatment plan outside the treatment room.

Slice
The single body section imaged in a tomography procedure.

Source
See radiation source.

Source-detector distance (SDD)
The distance measured along the central ray from the centre of the front surface of the source (X-ray focal spot or sealed radioactive source) to the active surface of the detector.

Source-to-image-distance (SID)
The distance measured along the central ray from the centre of the front of the surface of the source (X-ray focal spot of sealed radioactive source) to the surface of the image detector.

Source-surface distance (source-skin distance) (SSD)
The distance measured along the central ray from the centre of the front surface of the source (X-ray focal spot or sealed radioactive source) to the surface of the irradiated object or patient.

Spot film
A radiograph taken during a fluoroscopic examination for the purpose of providing a permanent record of an area of interest of to verify the filling of a void with contrast media.

Stray radiation
The sum of leakage and scattered radiation.

Survey
See radiation protection survey.

Target
The part of an X-ray tube anode assembly impacted by the electron beam to produce the useful X-ray beam.

Tenth value layer (TVL)
Thickness of a specified substance which, when introduced into the path of a given beam of radiation, reduces the kerma rate to one-tenth of its original rate.

Tomography
A special technique to show in detail images of structures lying in a predetermined

plane of tissue, while blurring or eliminating detail in images of structures in other planes.

Topogram

For CT, prior to making the cross-sectional scans, the CT scanner is normally used to obtain one or more radiograph-like reference images, as a way of identifying and documenting where the scans are to be made. These so-called topograms are prepared by keeping the X-ray source and the detectors stationary, and dragging the specimen through the fan-beam by moving the table. Also called scout scans, pilot scans, or scanograms.

Total filtration

The total of inherent filtration and additional filtration.

Useful beam

The radiation which passes through the opening in the beam limiting device and which is used for imaging or treatment.

User

Physicians and other responsible for the radiation exposure of patients.

Voxel

A volume element in the object being imaged. The mean attenuation coefficient of the voxel determines the CT (Hounsfield) number of the pixel.

Whole body dose equivalent (Hwb)

The dose equivalent associated with the uniform irradiation of the whole body.

Workload (W)

The degree of use of a radiation source. For X-ray machines operating at tube potentials below 500 kV, the workload is usually expressed in milliampere minutes per week. For gammabeam therapy sources and for photon-emitting equipment operation at 500 kV or above, the workload is usually stated in terms of the weekly kerma of the useful beam at one meter from the source and is expressed in grays per week at one meter.

Xeroradiography

The production of an image on a xerographic plate (e.g., electrically charged selenium) by the action of X-rays transmitted through the patient. (xeromammography: Mammography carried out by the xeroradiographic process.)

X-ray tube

Evacuated vessel for the production of x-radiation by the bombardment of a target, usually contained in an anode, with electrons accelerated from a cathode by an electric field. Thus: Rotating anode X-ray tube. Double focus X-ray tube.

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